MARCH 22, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION

621 A-T

Lighting Engineering Departments

Contents, page 3

XUM

FLEXIBLE SHAFT IDEAS for ENGINEERS

How fast can a power drive flexible shaft be operated?

GENERALLY SPEAKING power drive flexible shafts are designed to operate at speeds of 1,750 to 15,000 rpm. However, there are many applications where higher speeds are attained especially in the case of small diameter shafts.

Pictured is a portable tool in which an S. S. White flexible shaft operates at speeds up to 45,000 rpm. According to the manufacturer, the success of the application is due to the "very high operating speed and excellent torque transmission possible through the flexible shaft . . . which runs cool and without vibration."

High speed remote control flexible shafts meet many requirements

WHEN TRANSMITTING CONTROL to parts through small reversible electric motors, the use of high speed remote control flexible shafts should definitely be considered.

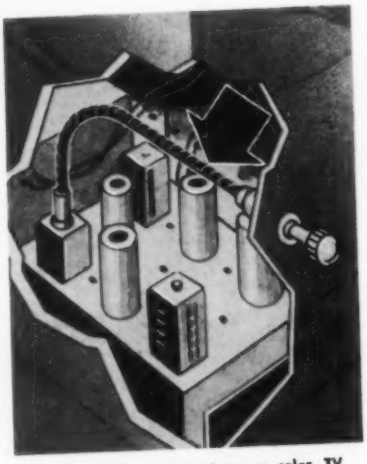
These shafts have been especially developed for intermittent operation in either direction of rotation at speeds up to 3,000 rpm.

But, their ability to operate around turns, the ease with which they can be installed, and their compactness offer definite advantages for many industrial applications.

We'll be glad to send details if you write stating your requirements.

Flexible Shafts offer big advantages when power or control goes around turns

Eliminating design and installation problems saves time and costs and improves performance

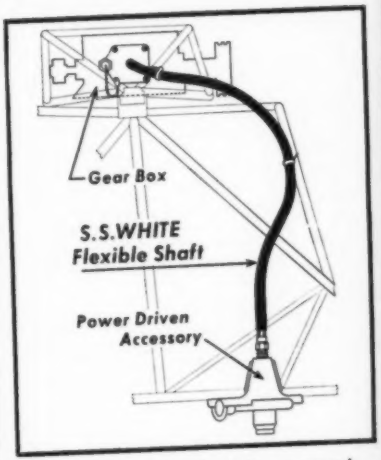


Regulating hue contrast on a color TV receiver is simplified by a flexible shaft coupling between control knob and circuit element. Note 90° turn.

ONE OF THE IMPORTANT ADVANTAGES of a flexible shaft is its ability to operate around turns and under conditions where alignment difficulties make a solid connection either impractical or uneconomical.

This fact is of prime importance when working out any design where power or control has to be transmitted between two parts. It assures greater design freedom. It simplifies manufacturing and assembly procedures. And it brings about important savings in costs as well as improvements in performance.

The two illustrations above graphically illustrate how S. S. White flexible shafts provided effective, cost-saving solutions to two power and control problems.



A power drive flexible shaft, run around intervening struts and frames, provides a dependable easy-to-install drive for a helicopter pump.

Think of your own equipment. Can you see where you could improve it through the use of flexible shafts? Our engineers will be happy to cooperate with you in making recommendations. There's no obligation, of course.

USEFUL FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

FS-3

FIRST NAME IN FLEXIBLE SHAFTS

S.S.White

S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

How to design with...

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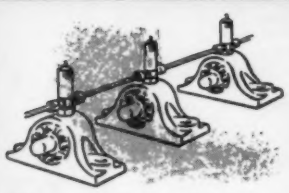
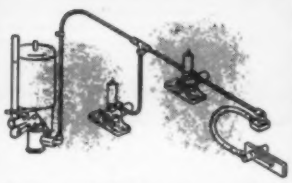
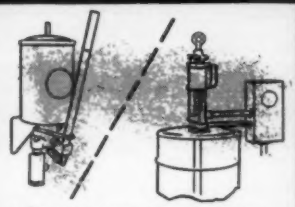
1. Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



2. Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for fast, neat installation.)



3. Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels available for moving parts.)



4. Provide central pump to supply lubricant to system. (May be ordinary hand pump or fully automatic barrel pump.)

Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

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- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers *exact* amount of lubricant to bearing.

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←Facing Page—ITEM 151

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XUM

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Export Sales: Geon International Corp. Great Neck, New York.

Other C/R Products
C/R Shaft and End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

March 22, 1956
Volume 28—No. 6

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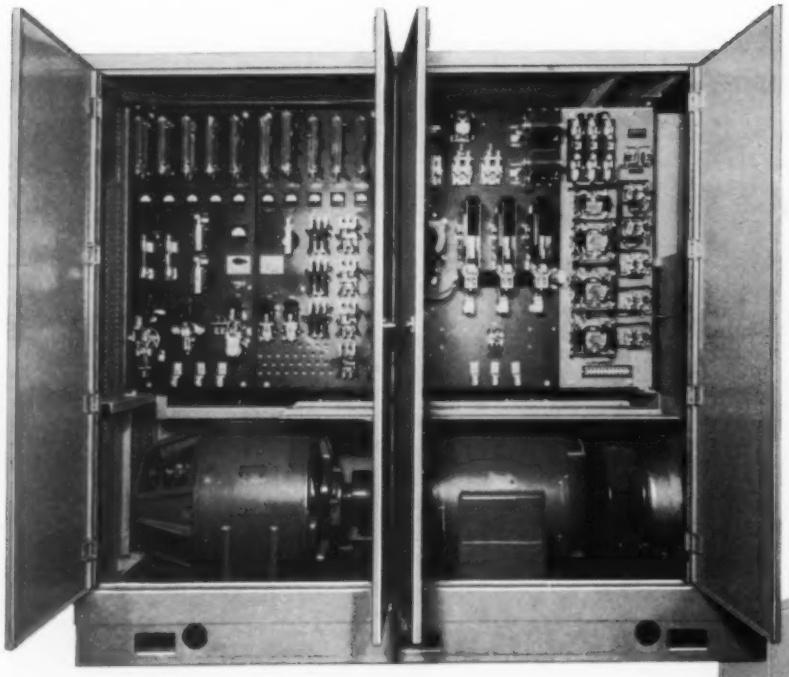
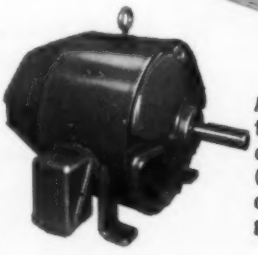


A control cabinet houses the a-c to d-c conversion unit, plus the control required for the particular application. At left is a 100-hp package.

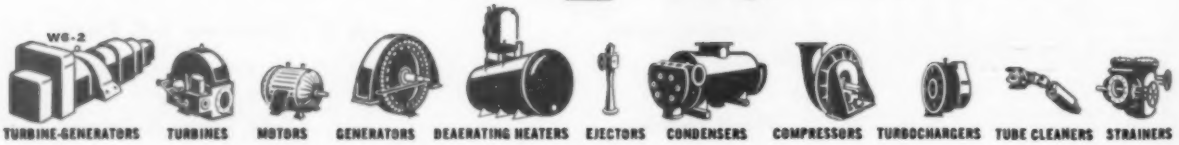
Power unit is housed in a pressurized sheet-metal cabinet with incoming air passing through filters, insuring long life and low maintenance costs. Cabinet has doors, front and rear, for easy access; doors, as well as center posts, are removable.

THESE PRE-ASSEMBLED, PRE-WIRED, easily installed power packages meet today's needs for flexible d-c motor performance from a-c power supply. They are designed for ratings up to 200 hp; speed ranges to 16:1 and up; 208, 220, 440 or 550 volts; 25, 50 or 60 cycles; 2 or 3 phase operation. Many modifications can be provided to meet special operating conditions. All components—power conversion and control—are backed by the Elliott Company's more than half-century experience in the manufacture and application of industrial drives. For complete information, write Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

ELLIOTT Company



A typical Elliott C-W d-c motor for use with adjustable speed drives. In addition to dripproof (shown) Elliott offers totally-enclosed, integral brakemotors and gearmotors.



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XUM

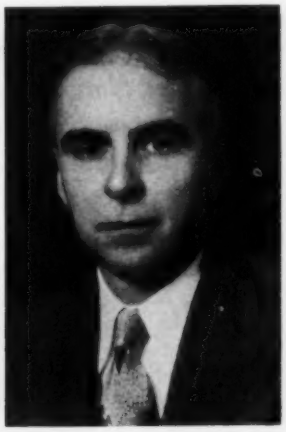
Engineering News Roundup

Magazine Editors Program First Design Conference in Philadelphia

Colin Carmichael

H. R. Clauser

George F. Nordenholt



Frank C. Oliver

THIS SPECIAL COMMITTEE of magazine editors has drafted the program for the ASME Design Engineering Conference at Philadelphia, May 14-17. The editors and their publications are: Colin Carmichael, *Machine Design;* H. R. Clauser, *Materials and Methods;* George F. Nordenholt, *Product Engineering;* and Frank C. Oliver, *Electrical Manufacturing.* Talks scheduled for the program cover the topics of valve analysis, training of design engineers, problems in miniaturization, the selection of materials, and the rewards for invention

Program Announced for First U.S. Design Engineering Show and Conference, May 14-17

Two Hundred Companies to Display Components, Materials, Finishes and Services for Consumer Items and Industrial End Products

Philadelphia—From May 14 to 17 this city's Convention Hall will be turned over to America's design engineers for the first combined show and conference arranged especially for them.

About 200 companies have engaged space to present exhibits of components, finishes, shapes and forms, and services which design engineers specify in creating a multitude of end products for consumer and industrial use. The collective theme for these displays is "Tomorrow's Products Are Tomorrow's Markets".

Along with the show, a conference is sponsored by the machine design division of the American Society of Mechanical Engineers. Registrations for the show may be obtained from Clapp & Poliak, Inc., 341 Madison Ave., New York 17. Further information on the conference is available from the ASME, 29 West 39th St., New York 18.

Programming of the conference has been arranged by the editors of four top professional journals that serve design engineers. The committee has engaged nine outstanding authorities to lead discussions on various aspects of design engineering. This is the program:

Monday, May 14

Value Analysis in Product Design. A. D. Bentley, specialist, value analysis services section, General Electric Co., Schenectady, N. Y., and W. L. Healy, supervisor, data bureau, Philadelphia Works, General Electric Co.

Tuesday, May 15

How to Get and Train Design Engineers. A panel discussion. Prof. Chester Linsky, department of industrial engineering, Pennsylvania State University, University Park, Pa.; A. A. Johnson, manager of engineering, switchgear division, Westinghouse Electric Corp., East Pittsburgh, Pa., and Dr. Bernard J. Covner, assistant vice-president, Dunlap & Associates, consultants, Stamford, Conn.

Wednesday, May 16

Selecting Engineering Materials for Products. W. A. Irvine, manager of production engineering, Maytag Company, Newton, Iowa.

Problems in Miniaturization. William C. Schmidt, systems development engineer, Merrimack Valley Laboratory,

Bell Telephone Laboratories Inc., Lawrence, Mass.

Thursday, May 17

Recognition and Reward for Invention. W. A. Steiger, manager, patent department, Westinghouse Electric Corp., East Pittsburgh, Pa.
Rights of the Employees' Inventions. George V. Woodling, patent attorney, Cleveland.

Portable TV Gives Battle Commanders More Eyes

Scout-Carried Cameras Free of Cable Connections

FORT MONMOUTH, N. J. — The Army now has a hand-held TV camera and back-carried transmitter that a soldier-scout can use to send battle pictures to his command post.

Developed by the Signal Corps Engineering Laboratories, the camera weighs 8 lb. The transmitter with built-in power supply weighs 47 lb.

By carrying his own battery pack, the TV soldier-reporter is freed from the cable connections of earlier models.

The voice accompanying the picture could be handled by the Signal Corps handy-talkie radio. In recent field tests at the Fort Monmouth Laboratories, the camera and radio operated together effectively as reconnaissance eyes and ears.

Recently developed by Army Signal Corps and RCA, this portable TV camera, battery-powered, frees operator from cable connections. Teams of cameraman and radio reporters extend commanders' view of battle situations

Pictures up to a mile distant can be picked up by the new camera and sent to a receiver one-half mile away.

The camera has four interchangeable lenses including a wide angle to view a broad sector, and a telephoto for far-away subjects. A pistol grip helps to steady the camera. It can also be mounted on a tripod for unattended operation. The unmanned camera might be stationed in a suspected radioactive area.

A TV receiver with a 10-inch aluminized picture tube is mounted in a jeep. The jeep's electrical system provides all needed power at the receiving point. Pushbutton controls at the receiver console enable a commander to monitor pictures taken by five cameramen in the field.

Plans Under Way for Third Mechanisms Conference

Well advanced in the planning stages is a Third Conference on Mechanisms to be cosponsored by the Mechanical Engineering Department of Purdue University and MACHINE DESIGN.

Success with the first two conferences in 1953 and 1954 has guided planners of the third in arranging for papers of direct concern to design engineers. In addition, designers attending the Third Conference will have the opportunity to participate in informal discussions on problems directly in their own lines.

Dates of the Third Conference are Thursday and Friday, May 24 and 25. Three paper sessions will cover the synthesis of mechanisms, mechanisms for intermittent motion, and practical factors in cam design.

In addition to general mechanism problems, group discussions will consider problems in particular industries.

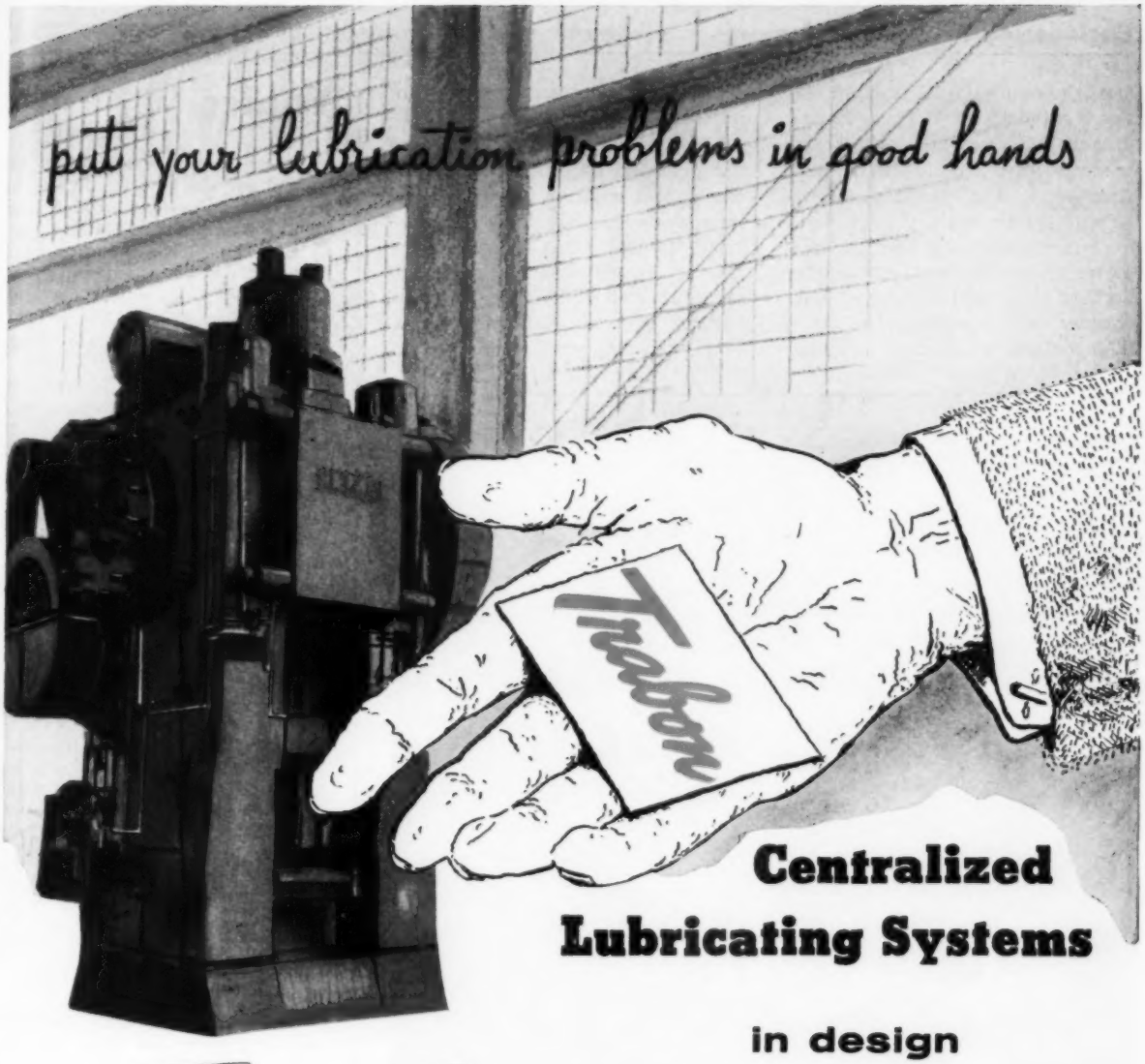
The planning committee is composed of industry members and representatives of the cosponsors. Planning cochairmen are A. S. Hall of Purdue and Benjamin L. Hummel of MACHINE DESIGN.

Further details of registration and program will appear in coming issues of MACHINE DESIGN.

A heavy-duty ignition system for high-compression gasoline engines, developed by the Scintilla division of Bendix Aviation Corp., combines a new type magneto with the company's Hi-V transformer coil. This combination was engineered to

Front Cover

Taking a bit of artistic license, cover artist George Farnsworth has used a heavily shadowed silhouette of a drafting board as a central theme. To find out how to get rid of such heavily shadowed areas, read John Neidhart's article on lighting engineering departments.



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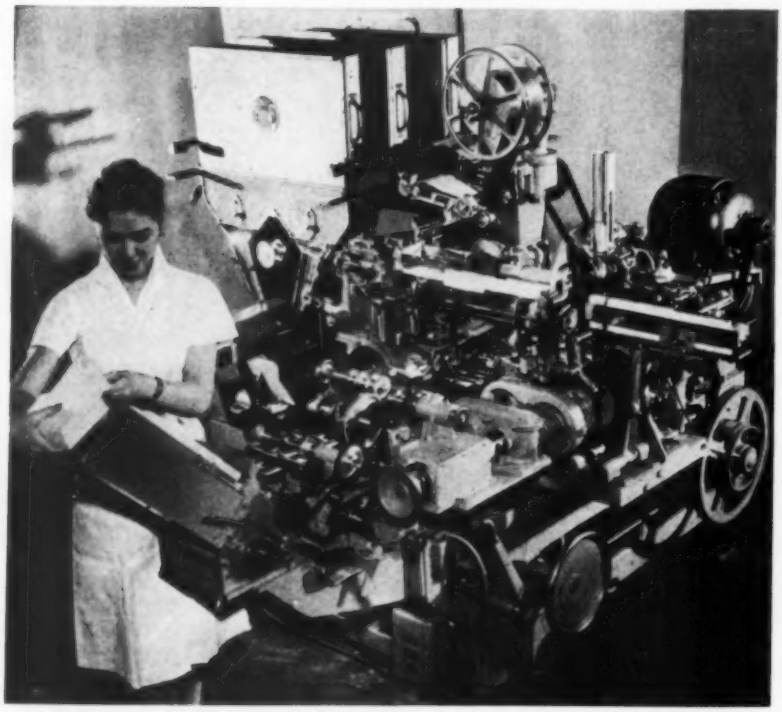
meet the requirements of large stationary industrial engines having 6 to 16 cylinders and with horsepower ratings from 1000 to more than 4000. The system is reported to deliver high voltage with minimum spark plug erosion. Adjustment of the magneto master breaker is normally required only once a year; the magneto has a high output at normal cranking speeds and does not require an impulse coupling for starting. Advancing or retarding the spark is accomplished by either manual or mechanical rotation of the entire magneto section which assures constant voltage. One model of the ignition system is suitable for installation on odd-firing engines and for use with dual-ignition systems with staggered timing.



HARD-BOX CIGARETTE PACKER, said to be the first of its kind developed in the U. S., was completed recently by American Machine and Foundry Co. for Gardner Board and Carton Co. It requires only one attendant; turns out 120 filled packs per minute. The machine receives box blanks, folds and glues cardboard, adds lining and cigarettes and places revenue stamp

New Machine Types Words All At Once

Typewriter Keys Coded For Common Phrases

NEW YORK—A newly developed machine announced by International Business Machines Corp. writes entire words or phrases at the touch of a single key. Called the Wordwriter, the automatic device can print any one of forty-two 18-character words or phrases at the rate of 150 per minute. The new machine can automatically capitalize and hyphenate words where necessary.

A standard IBM typewriter was modified by adding a special memory system. Pressing a switch converts the machine into a Wordwriter by connecting the memory unit. Commonly used words or phrases may be set up in the memory unit and each assigned a particular key. By pressing the appropriate key the machine auto-

Topics

Snooze alarm is the name of a new GE alarm clock. When it goes off, you reach over and turn it off—you think. It lets you rest 15 minutes, then goes off again. Punching the button again gives you another 15 minutes. This presumably goes on until you finally get up and really shut the thing off.

• • •

An automatic car parking device has recently been patented. All you do is pull up parallel to the car ahead, shift into reverse and throw a switch. The device then operates the steering gear while you back in. For those do-it-yourself drivers, or those who just don't trust mechanical devices, the control can be adapted to give audible signals to tell the driver just when to turn and how much.

• • •

Speedometers for outboard motors will soon be installed by Firestone on their line of marine engines. Officially called "Knotometers" the gadgets will read both knots and mph.

• • •

Monorail line, first in U.S., began trial operation recently in Houston, Tex. Although less than 1000 ft long, the line demonstrates a possible solution to the commuter tangle in large cities.

• • •

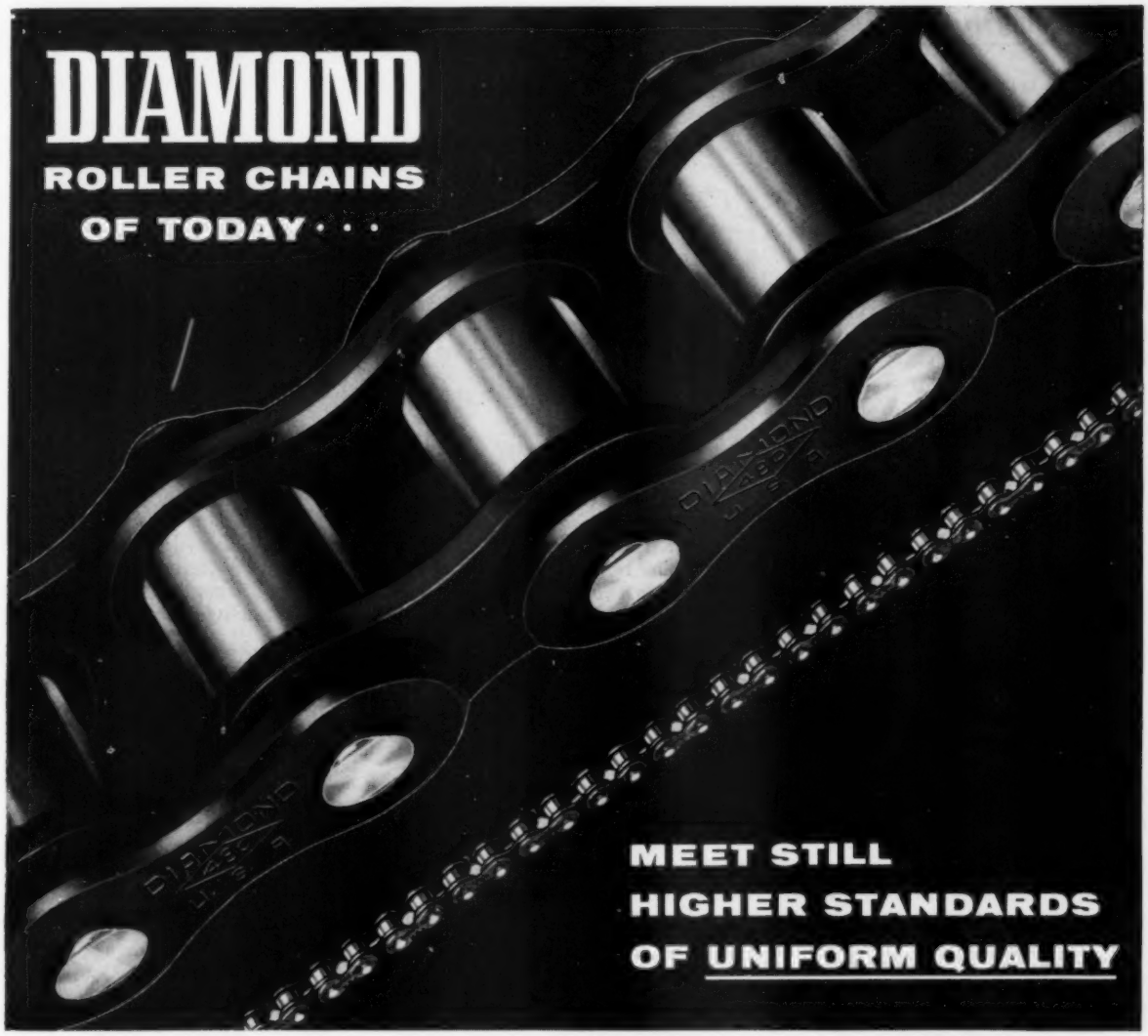
Freshman engineering curriculum at Purdue has been tailored to the student's high school record and ability. If he meets the standard entrance qualifications, the student takes the regular two-semester freshman course. If he meets only the minimum requirements, he is required to take a lengthened freshman curriculum.

• • •

World's first gas-turbine locomotive using coal as fuel will soon be built. Tests on the turbine unit being run at Alco Products Inc. are expected to be completed this year.

• • •

Vertical-rising airliners are possible according to three NACA aeronautical experts. They've designed a hypothetical 40 to 50-passenger transport about the size of a DC-4 that hypothetically will be able to take off straight up. Engines mounted on the wing are rotated vertically for take off and horizontally for level flight.



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This concentration of effort on one product is good reason for the *uniformity* of quality of Diamond Roller Chain, the great reserve strength, the longer life dependability that mean lower cost, improved product and output. The Diamond trade mark is synonymous with highest quality.

In your factory operations, Diamond motor drives hold production speeds at their maximum, and avoid power and output losses. There is practically no end to the applications of Diamond Roller Chains. Our engineering staff is ready at all times to make practical recommendations.

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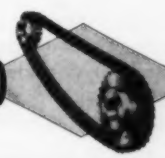

DIAMOND ROLLER CHAINS

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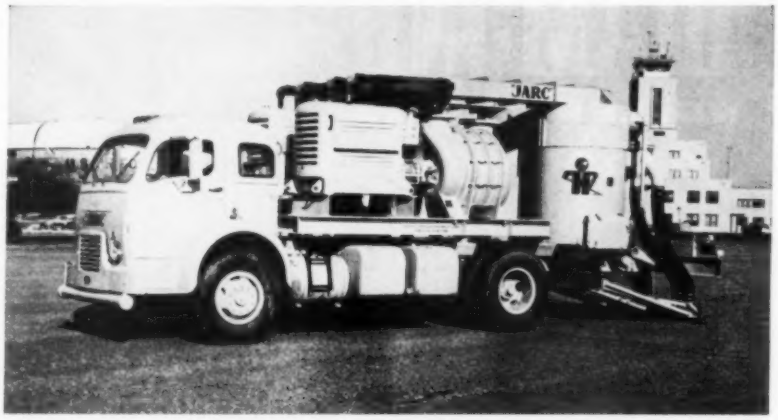
matically types out the desired word or phrase.

Two of the machine's features are "optional capitalization" and "conditional hyphenation." If a phrase or word appears at the beginning of a sentence, the initial letter is automatically capitalized.

In conditional hyphenation, the typist is relieved of having to think of the written word's position in the line. If the word comes at the end of the line, the machine automatically breaks the word at the right place and completes it on the next line. If the word is written near the middle or at the left of the line, hyphenation is disregarded.

Phrases like "Dear Mr." or "Thank you for" may be set up in advance on one key. An entire complimentary closing may be set up on one key. The machine will type the closing, the letter writer's name, title and even the initials of the signer and the typist.

No plans for marketing the machine have been announced, according to IBM.



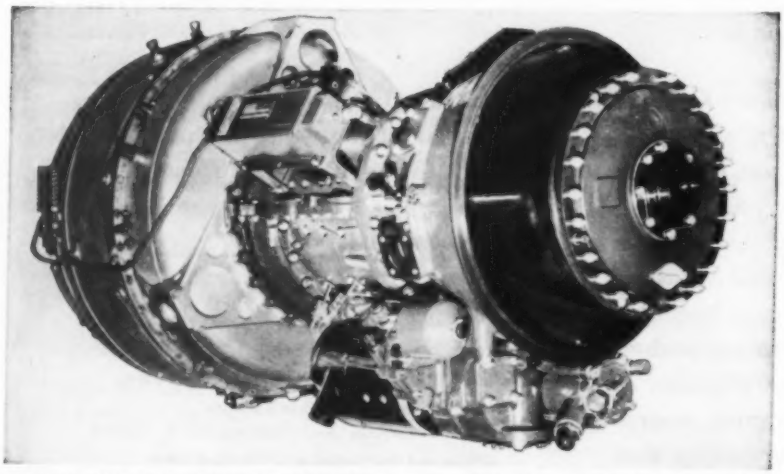
BIGGEST VACUUM CLEANER is this vehicle developed by U. S. Hoffman Machinery Corp. to clear litter from runways used by jet planes. USAF has found that extensive damage is caused by debris sucked into engine air scoops. The truck is named JARC (jet aircraft runway cleaner); clears 2-million sq ft in about 8 hr. Its nozzles suck in air at 350 mph. Two heavy duty exhausters are the equivalent of 1200 home-type cleaners

---

New nickel-base brazing alloy features low brazing temperature, good flow and wetting properties, thin to moderate fillet formation and no erosion during brazing. The new material introduced by Wall Colmonoy Corp. is called Nicrobraz No. 10.

It is considered suitable for low-temperature joining of stainless steels, nickel and cobalt-base alloys, low-alloy and carbon steels, copper and other base metals having a melting point above 1900 F for applications involving service temperatures from 60 to 1500 F.

Nicrobraz can be applied with a brush, or by cold or hot spray methods.



FREE-POWER TURBINE ENGINE the first built in U.S., is this Lycoming model XT53-L-1. The new gas turbine engine will power the Bell Aircraft XH-40 utility helicopter. The engine's power turbine is mechanically independent of the compressor and compressor turbine. Output shaft power may be held nearly constant over wide range of shaft speeds. Engine has 23-in. diam.; 47.6-in. length; weighs 460 lb; delivers 825 shaft hp. It can operate on several fuels, including automobile gas

Turnpike Toll Tally Tells Tonnage

Automatic System Weighs Moving Vehicles

SCHENECTADY, N. Y.—The beam of an electronic eye is the key component of a toll collection and audit system developed by IBM and installed on the recently completed Ohio Turnpike. At all interchanges and terminal points along the new road, the system weighs and classifies vehicles automatically. The system operates while the cars and trucks are in motion.

An attendant inserts a fare card into a toll recorder, notes the number of axles on the vehicle passing, and pushes the appropriate key on the recorder. Pushing the key automatically totals the individual axle weights. It also registers the vehicle's classification on the fare card.

When the attendant pushes the key, an "axle group indicator" on

NEW DEPARTURES OF TODAY

From the expanded

facilities of New Departure...

a complete line of

miniature bearings!

The most exacting needs of today's precision industries are met by New Departure's complete line of miniature ball bearings, 3/8" (.375") outside diameter and smaller.

Made with extreme accuracy, these tiny steel "jewels" are assembled, torque-tested, and packed in pressurized, atmosphere-conditioned areas of surgical cleanliness, assuring performance and dependability of the highest order.

For full information about miniature bearings, or for engineering help on your bearing problems, contact New Departure, Division of General Motors, Bristol, Conn.

GM GENERAL MOTORS

NEW DEPARTURE

BALL BEARINGS

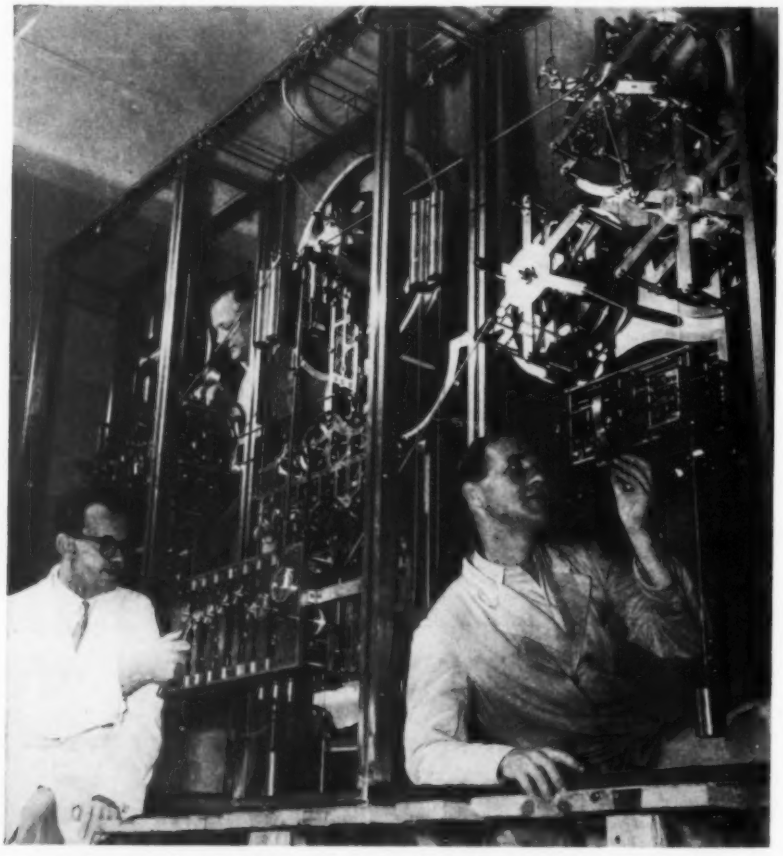
NOTHING ROLLS LIKE A BALL

—ITEM 159—

XUM

top of the toll recorder has already received the correct number of axles from the photoelectric system. Should the wrong key be punched, the axle group recorder lights up and tells the attendant the correct number of axles and at the same time locks to prevent improper validation of the fare cards.

The fare card is given to the vehicle operator who presents it at the exit gate, along with his toll. The system automatically reweighs the vehicle at the exit interchange and compares the weight class punched by the entrance recorder. The equipment also reads the number of axles and the time punched by the entrance recorder.



Master timer in Copenhagen marks time throughout world, notes festive days

Astronomical Clock To Run 1000 Years

Danish King Starts Remarkable Timekeeper

COPENHAGEN, DENMARK — Recently completed in the Town Hall of Copenhagen is a timepiece which may be the world's most remarkable mechanical clock. It is expected to run 1000 years without stopping and to deviate only 0.4-second every 300 years.

The clock is literally the lifework of its designer, Jens Olsen, for he died before completion of his masterpiece. In a ceremony honoring the craftsman, Danish King Frederik and Olsen's granddaughter together pressed a button to start the mechanism.

Probably the ultimate to date in mechanical astronomical timekeepers, the clock gives Central European Time, sidereal time, local Copenhagen time, true solar time, the equation of time, sunrise and sunset by mean time and true solar time, the time of day anywhere in the world, the revolutions of the planets, eclipses of the sun and moon, and the rising and setting of the stars.

Multiple dials for multiple data

It also shows the day of the week, the date, the name of the month, and the year. Its calendar shows the phases of the moon and all the movable feasts in the church year.

The clock is made up of eleven movements interconnected partly through arbors or trains of wheels and partly through steel ribbons. Ten of the eleven assemblies have one dial each. The eleventh, without a dial, serves as a control.

The frame of the main work is a bronze casting; all arbors and pinions are of highly polished steel; and the escapement is a Dennison type which gives constant impulse. The impulse arms are fitted with impulse pins of white synthetic sapphires. The escape wheel makes one revolution in 10 sec.

The clockwork has a seconds pendulum consisting of a rod of Invar steel and a bob made of three steel cylinders. The center steel cylinder has a compensating device made of Ebonite.

The clock is driven by weights and is designed to go eight days before rewinding, with a four-day reserve of driving power. To prevent the train from momentary stoppage during winding, the barrel is provided with a differential causing the power to act constant-

HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Bearings: Critical Criteria of Motor Life!

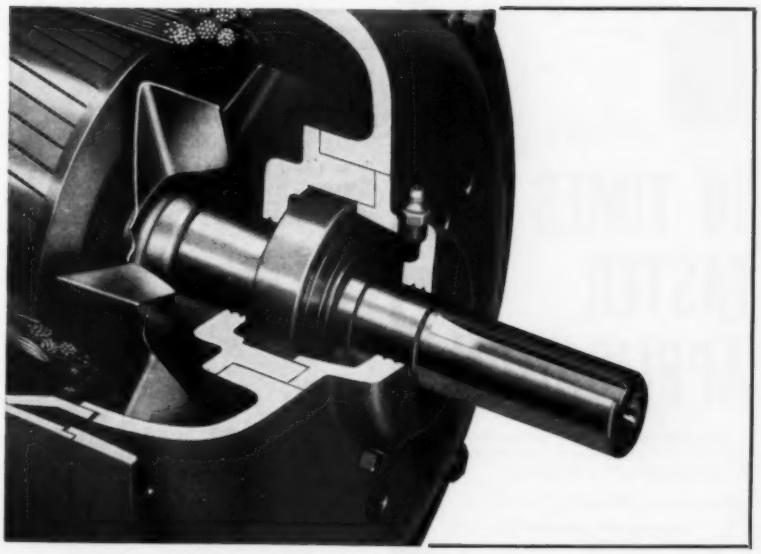
Surveys among motor service shops have shown repeatedly that bearing breakdown is the most common cause of motor failure. With the air gap between rotor and stator measured in thousands, a very small shaft misalignment due to worn bearings is certain to shorten a motor's working life. Hence Howell's attention, in the new Series 100 re-rated motor design, to full bearing protection.

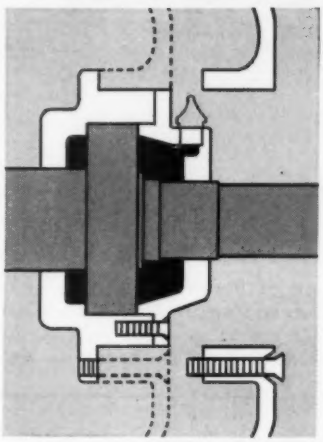
Howell's fully-enclosed end plate cavities incorporate an inner bearing cap that seals out any dust drawn into the motor by the ventilating air stream. In fact, in Howell's Series 100 Totally Enclosed Fan-Cooled motors, cartridge-type bearings are used, that stay protected even when the end plate is removed for servicing.

In all Series 100 motors, Howell uses double shielded bearings with the balls shielded on both sides by steel rings, that are sealed in the outer race and fit within .010 inch clearance of the inner race. Consider the better service inherent in such bearings against the open-type employed in many re-rated motors.

Finally, Howell does everything possible to insure that the Series 100 motor bearings are protected from common lubricating malpractices. Top ball grease fittings inhibit the entrance of dirt that may cling to the maintenance man's grease gun tip. Most important, the Howellube greasing system doesn't flush the grease through the bearing and pack it tight. Instead, the grease enters and exits from the grease relief on the same side of the bearing, with the oils in the grease migrating properly into the races. Result: less chance for over-lubrication, less chance of bearing failure.

When you compare motors, compare them on these details of bearing design. Howell Series 100 motors are worth investigating from any standpoint.





Howell Cartridge Construction Assures Full Bearing Protection

Cross section above shows the inner bearing cap, outer bearing cap and end-plate of Howell Series 100 TEFC motors. Diagram at left indicates how end-plate can be removed without opening cartridge. Bearing remains fully protected and free from dust and other abrasive matter during motor disassembly for servicing or inspection.

At right, a typical double shielded bearing as used in Howell Series 100 motors.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, explosion-proof, and totally enclosed non-ventilated.

Write for new Bulletin N-100-R

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

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Headless
SET SCREWS

10 TIMES FASTER APPLICATION

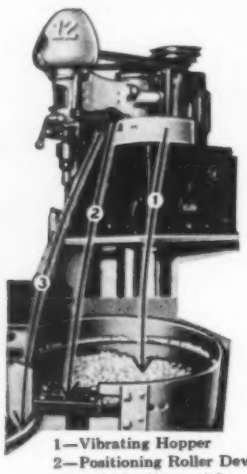
Can be used for practically any set screw application. We offer special mechanism* for applying Headless Set Screws.

Offers many unusual advantages:

Automatically inspects diameter; rejects misfits.

Takes less floor space; permits smaller inventory, faster delivery.

Reduces floor loss, cross-threading etc.



1—Vibrating Hopper
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3—Tube leading to job

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Set Screw & Mfg. Co. 28 Main St. Bartlett, Ill. (Chicago suburb)

We specialize in Solving Puzzling Set Screw Problems

—ITEM 161—

ly in one direction.

The case is designed to give full view of the mechanisms inside. Dust is excluded by air pumped in at constant pressure, humidity and temperature.

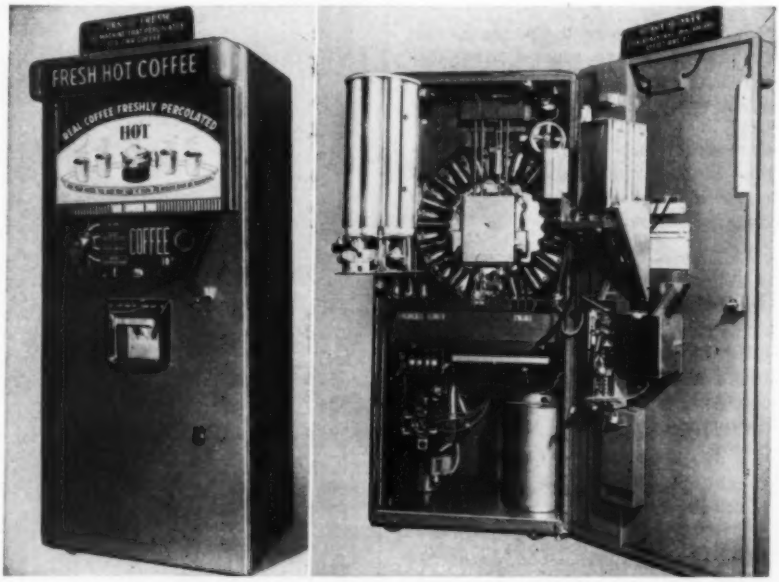
Sixteen Cups And Whaddya Get?

Another Big Potful That's Tastier Yet

CHICAGO—Freshly percolated coffee is automatically produced as it is used in a new vending machine. Forty 16-cup percolators are mounted in two rows on a wheel-like rack. As one percolator is emptied, the rack is electronically actuated to rotate and position a fresh percolator for brewing.

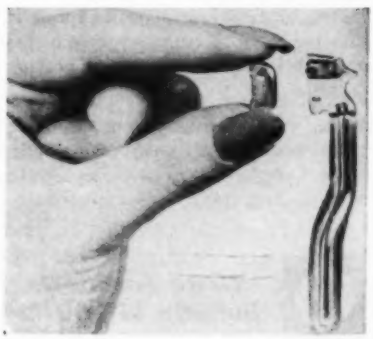
An integral electrically operated unit heats water as it is brought in from a cold water outlet. Heated water is carried by a tube to a tank above the percolators, where the correct amount is measured and forced through a percolator into one of two dispensing tanks in the hub of the rack.

Coffee is served by the Perk-O-Fresh machine at a temperature of 150 to 160 degrees. Cream and sugar can be mixed with the beverage according to a dialed selection. An electronic timer controls periodic disposal of unused coffee.



Front of Perk-O-Fresh machine has dial for selecting coffee black or with cream and/or sugar. Machine's insides include rotating rack of 40 percolators, water heater at lower left, waste receptacle at lower right and paper cup holder, upper left. Tanks on the back of the door hold cream and sugar

Change of Characters Made Easy for Typists



NEW YORK — Removable and interchangeable typewriter type is featured on the 1956 Remington standard typewriter. The typist alone can change one or all of the characters on the machine in a few minutes.

The type blocks in the new machine snap into place in spring

XUM

clips at the end of the type bars. Only tweezers are needed to remove blocks and change characters. Special characters are available for mathematics, medicine, engineering, music and foreign languages.

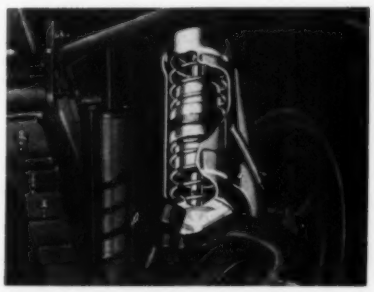
Another feature of the new Remington machine is a 44-character keyboard which provides four extra characters in its standard arrangement. These are section and paragraph marks, a plus sign and an equal sign.

Shock-Absorbing Devices Smooth Out Truck Riding

Vibration Absorbers Compensate for Road Shocks

PONTIAC, MICH.—Vibration absorbers for light trucks, and air-filled rubberized bellows in truck-trailers, will provide smoother and safer operation, according to General Motors officials.

The vibration absorbers act to smooth out road shocks and vibrations before they reach the truck's frame. Mounted behind the front



Vibration absorber mounted on the brake backing plate of a light truck's front wheel consists of an 11.8 by 4.4-in. metal cylinder containing a 12-lb steel weight sandwiched between two coil springs. The weight slides along a steel rod to damp vibration

wheels, the dampers counteract shock with floating weights that slide downward in metal cylinders when the truck goes over bumps. The weight is suspended between two springs, and spring tension is such that the vibration frequency of the damper weight opposes the

(*Continued on Page* 22)

Give your equipment the best circulation system...
If the equipment you design and build depends on the flow of liquid—be sure you specify Ingersoll-Rand Motorpumps to power the circulation system. Ingersoll-Rand Motorpumps are ruggedly constructed, yet compact in design to deliver the volume and pressure you require. From small ¼ hp to 75 hp models, these pumps give you the high efficiency and dependable performance that have made Ingersoll-Rand Motorpumps industry's standard of comparison.
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9-324

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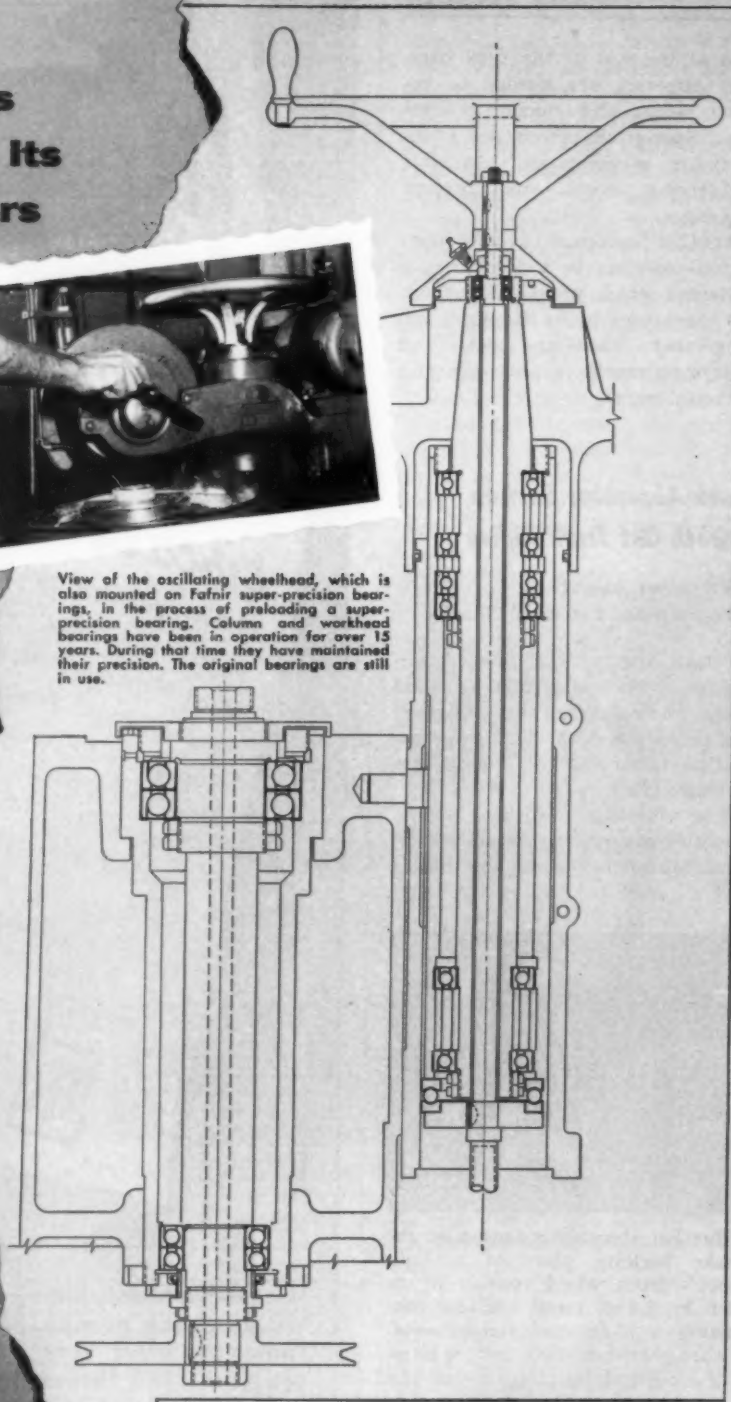
For More Information Circle Item Number on Yellow Card—page 19

How a precision surface grinder is designed to hold its precision for years

The job of preloading super-precision ball bearings calls for grinding precise amounts of stock from the faces of bearing rings. To obtain such results with a satisfactory degree of efficiency requires a grinder designed to to maintain maximum rigidity and precise swiveling of its wheelhead arm plus precise rotation of its work spindle.

The diagram at the right shows how such rigidity is built into a precision surface grinder. All bearings indicated except the thrust bearing at the bottom of the column which supports the wheelhead arm are Fafnir super-precision, preloaded types. The use of these Fafnir ball bearings has resulted not only in work of dependable accuracy and finish, but also longer machine life. For other application data on Fafnir super-precision bearings plus dimensional and load rating details, write for Fafnir Precision Ball Bearing Catalog. The Fafnir Bearing Co., New Britain, Conn.

View of the oscillating wheelhead, which is also mounted on Fafnir super-precision bearings, in the process of preloading a super-precision bearing. Column and workhead bearings have been in operation for over 15 years. During that time they have maintained their precision. The original bearings are still in use.



FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

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MACHINE DESIGN
READER SERVICE

Reader Information Service

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for More Information . . .

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and tile of article in the place provided on the Yellow Card.

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25	55	85	115	145	175	205	235	265	295	325	355	385	415	445	475	505
26	56	86	116	146	176	206	236	266	296	326	356	386	416	446	476	506
27	57	87	117	147	177	207	237	267	297	327	357	387	417	447	477	507
28	58	88	118	148	178	208	238	268	298	328	358	388	418	448	478	508
29	59	89	119	149	179	209	239	269	299	329	359	389	419	449	479	509
30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

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COMPANY _____

PRODUCT MANUFACTURED _____

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CITY _____ ZONE_____

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Do not use this card after May 22, 1956

MACHINE DESIGN
MAR. 22, 1956

Circle item number for information on products advertised or described or copies of literature.

1	31	61	91	121	151	181	211	241	271	301	331	361	391	421	451	481
2	32	62	92	122	152	182	212	242	272	302	332	362	392	422	452	482
3	33	63	93	123	153	183	213	243	273	303	333	363	393	423	453	483
4	34	64	94	124	154	184	214	244	274	304	334	364	394	424	454	484
5	35	65	95	125	155	185	215	245	275	305	335	365	395	425	455	485
6	36	66	96	126	156	186	216	246	276	306	336	366	396	426	456	486
7	37	67	97	127	157	187	217	247	277	307	337	367	397	427	457	487
8	38	68	98	128	158	188	218	248	278	308	338	368	398	428	458	488
9	39	69	99	129	159	189	219	249	279	309	339	369	399	429	459	489
10	40	70	100	130	160	190	220	250	280	310	340	370	400	430	460	490
11	41	71	101	131	161	191	221	251	281	311	341	371	401	431	461	491
12	42	72	102	132	162	192	222	252	282	312	342	372	402	432	462	492
13	43	73	103	133	163	193	223	253	283	313	343	373	403	433	463	493
14	44	74	104	134	164	194	224	254	284	314	344	374	404	434	464	494
15	45	75	105	135	165	195	225	255	285	315	345	375	405	435	465	495
16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497
18	48	78	108	138	168	198	228	258	288	318	348	378	408	438	468	498
19	49	79	109	139	169	199	229	259	289	319	349	379	409	439	469	499
20	50	80	110	140	170	200	230	260	290	320	350	380	410	440	470	500
21	51	81	111	141	171	201	231	261	291	321	351	381	411	441	471	501
22	52	82	112	142	172	202	232	262	292	322	352	382	412	442	472	502
23	53	83	113	143	173	203	233	263	293	323	353	383	413	443	473	503
24	54	84	114	144	174	204	234	264	294	324	354	384	414	444	474	504
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16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497
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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

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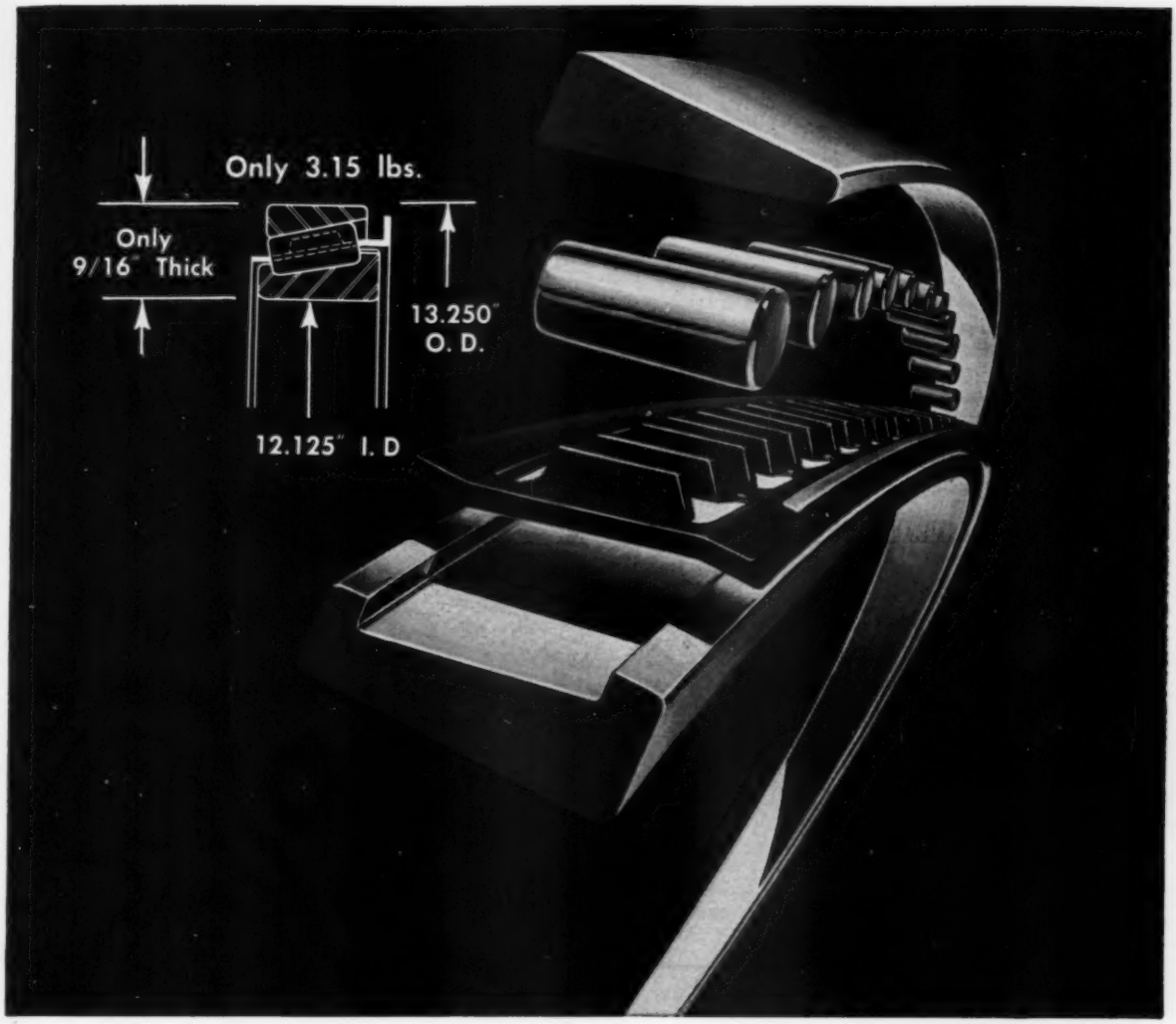
Reader's Service Dept.



Kaydon...
world's thinnest tapered roller bearings

Reali-Slim — that's the name we've given our line of extremely thin-section, lightweight bearings. The bearing shown above is a *Reali-Slim*. *Reali-Slim* bearings are really strong, too! The single row, tapered roller bearing we're talking about, here, has a 33,000-lb. radial capacity—with 38,200-lb. thrust capacity. Over 1-ft. in diameter, yet it weighs only 3.15 lbs! These figures tell how *Reali-Slim* bearings combine minimum section with high strength and long life.

If you're looking for a whole new concept in thin-section, lightweight bearing design — look at Kaydon's *Reali-Slim* line. In addition to hundreds of *Reali-Slim* standard sizes, there's a big variety of special races and separators to meet special applications. Kaydon engineers are prepared to give you valuable help with your application problems.

For more information write Kaydon of Muskegon. Ask for engineering Catalog No. 54-RS detailing:

★ ***Reali-Slim Ball Bearings*** — in Conrad, angular contact and 4-point contact types are available in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40.000".

★ ***Reali-Slim Roller Bearings*** — in radial and taper roller types are available in cross sections from 9/16" and in bore diameters from 5" to 40.000".

C-552

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings.

—ITEM 164—
For More Information Circle Item Number on Yellow Card—page 19

XUM

Mr. Design Engineer:

This is your Reliable non-sticking relay

New plunger construction features put this steel-clad Durakool timer-relay in the "fail-safe" group. Mechanical life now 5 to 6 times longer. Any operate-release time combination from 0.15 sec. to 20 sec. — either normally open or normally closed.

GUARANTEED FOR AC-DC APPLICATION
and:

- ★ Extra long life
- ★ No false contacts
- ★ Tamper proof (Timing not changeable)
- ★ Low cost timer

See telephone directory for local distributor, or write.
Send for Bulletin 800

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 Weston Rd., Toronto 9, Canada

Durakool
ALL-STEEL MERCURY
Timers

—ITEM 165—

Engineering News Roundup

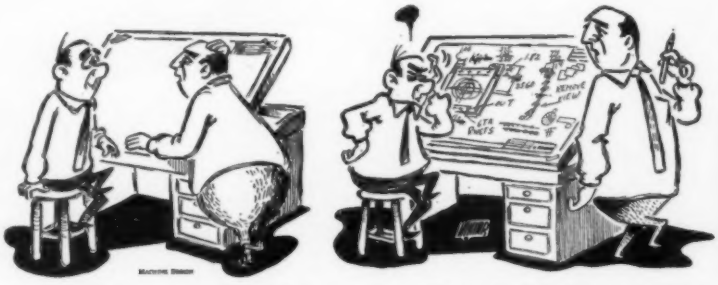
(*Continued from Page* 15)

vibration frequency of the vehicle's front wheels. Riding comfort is improved, as is the truck's road hugging ability.

Air ride suspension, replacing convential metal leaf springs, is now installed in an experimental truck-trailer combination and will be ready for production models late this year. Among advantages claimed for the system are smooth ride, long chassis life, reduced maintenance, feasibility of more lightweight packaging with reduction of cargo breakage, increased payload, better load distribution.

The system is composed basically of air bellows, leveling valves, air beams, air chambers and an air storage tank. The tractor has six bellows; the trailer has four. All moving parts are rubber-mounted. The valves regulate air to provide proper inflation of bellows for all load conditions.

It Never Fails . . .



"Just want to remind you that we stress neatness and cleanliness around here."

"Thought I'd give you the recent changes before you roll it up."

Meetings

AND EXPOSITIONS

April 4-7—

National Screw Machine Products Association. Annual Meeting to be held at the Schroeder Hotel, Milwaukee, Wis. Additional information may be obtained from society headquarters, 2850 E. 130th St., Cleveland 20, O.

April 8—

Packaging Machinery Manufacturers Institute. Spring Meeting to be held at the Dennis Hotel, Atlantic City, N. J. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

April 8-12—

Scientific Apparatus Makers Association. Thirty-eighth Annual Meeting to be held at the Belleview-Biltmore, Belleair, Florida. Additional information may be obtained from society headquarters, 20 North Wacker Dr., Chicago 6, Ill.

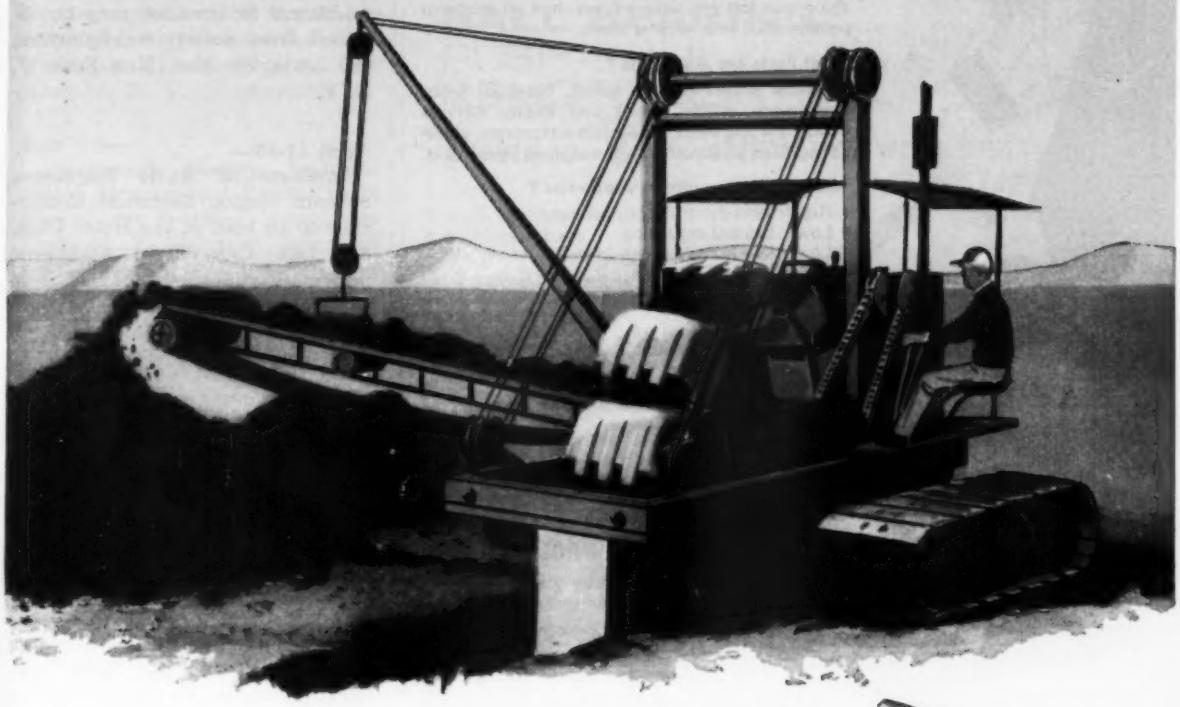
April 9-12—

Society of Automotive Engineers, Inc. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at Hotel Statler, New York, N. Y. Additional information may be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

April 10-11—

American Society of Mechanical Engineers. Machine Design Division Conference to be held at the Bancroft Hotel, Worcester, Mass. Additional information may be obtained from society headquarters,

Every sleeve bearing must be precisely engineered for the job to be done. Load, speed, temperature and many other critical requirements must be met. Continuous research, engineering and metallurgy enables us to meet these exacting requirements on a wide variety of mechanical assemblies . . . for which we produce millions of bearings each year.



Bearings for Industry

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

FEDERAL-MOGUL DIVISION

FEDERAL Mogul

SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

XUM

Here are the NEW

NYLASINT® PARTS

Nylon components with superior dimensional stability and wear resistance—produced by high speed cold pressing, followed by batch oil sintering under the melting point.

Nylasint Parts are . . .

formed from specially processed finely divided nylon powders (particles of less than 40 microns) compounded with various fillers.

What Parts are Available?

Moldable shapes such as rollers, bearings, bushings, gears, profile shapes and sliding surfaces obtain new and wider application advantages, eliminating flash problems with lower mold investment.

What are their superior properties?

- Higher heat distortion temperature
- Lower thermal expansion
- Lower hygroscopic expansion
- Higher abrasion resistance
- Lower coefficient of friction

A high percentage of various fillers can be employed to provide specific mechanical, electrical or thermal characteristics.

Write for complete technical data on how to apply Nylasint Parts in your industry.

Licensed Fabricators and Design Engineers:
Dixon Sintaloy, Inc., Stamford, Conn.,
Halex Corp., Plymouth, Mich.

POLYMER NATIONAL POLYMER PRODUCTS, INC.
A Subsidiary of The Polymer Corporation
Reading, Pennsylvania

—ITEM 167—

NEW! low-price Fast's Coupling

. . . for light and medium drives!

It's the new MODEL B—lighter, smaller, with all the famous Fast's features—yet priced at a new *low!* The new MODEL B is designed for light-to-medium drive units such as fans, blowers and pumps—where cost is important. Now these products can afford the rugged construction and trouble-free performance of genuine Fast's Couplings.

All steel, dust and moisture proof with metal seal, the new MODEL B is available for shaft sizes up to 2⅝". Sold with Koppers *free* engineering service!

Find out how the new Fast's MODEL B can solve your coupling problem. Write, wire or phone: KOPPERS COMPANY, INC., Fast's Coupling Dept., 3503 Scott St., Baltimore 3, Maryland.

KOPPERS

THE ORIGINAL *FAST'S Couplings*

Engineered Products Sold with *Service*

—ITEM 168—

News Roundup

29 West 39th St., New York, N. Y.

April 10-12—

Metal Powder Association. Annual Meeting and Show to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 420 Lexington Ave., New York 17, N. Y.

April 11-13—

Institute of Radio Engineers. Seventh Region Technical Conference to be held at the Hotel Utah, Salt Lake City, Utah. Additional information may be obtained from society headquarters, 1 East 79th St., New York, N. Y.

April 16-17—

American Society of Mechanical Engineers. Gas Turbine Power Division Conference to be held at Hotel Statler, Washington, D. C. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

April 18-19—

National Industrial Research Conference to held at Hotel Sherman, Chicago, Ill. Sponsored by Armour Research Foundation of Illinois Institute of Technology. Joseph J. Kowal, Technology Center, Chicago 16, Ill., is conference secretary.

April 19-20—

Environmental Equipment Institute. Second Annual Meeting of the Science Section to be held at Sheraton Hotel, Chicago, Ill. Additional information may be obtained from H. F. Sander, meeting chairman, c/o Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 23-25—

American Zinc Institute & Lead Industries Association. Combined Annual Meeting to be held at Hotel Statler, St. Louis, Mo. Additional information may be obtained from Robert L. Ziegfeld, 420 Lexington Ave., New York 17, N. Y.

April 28-May 6—

International Automobile Show to be held at the New York Coliseum, Main Exhibition Hall, New York City, N. Y. Additional in-

XUM

formation may be obtained from Charles Snitow Organization, 331 Madison Ave., New York 17, N. Y.

April 30-May 2—

Metal Treating Institute. Spring Meeting to be held at the Roosevelt Hotel, New Orleans, La. C. E. Herington, 271 North Ave., New Rochelle, N. Y., is secretary.

May 2-4—

Investment Casting Institute. Spring Meeting and Exhibit to be held at the Warwick Hotel, New York, N. Y. Harry P. Dolan, 27 E. Monroe St., Chicago 3, Ill., is executive secretary.

May 2-4—

Industrial Fasteners Institute. Annual Meeting to be held at the Homestead, Hot Springs, Va. R. B. Belford, 1517 Terminal Tower, Cleveland 13, O., is secretary.

May 7-11—

American Welding Society. National Spring Technical Meeting and Welding Show to be held at Hotel Statler and Memorial Auditorium, Buffalo, N. Y. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

May 8-11—

American Society of Mechanical Engineers. Metals Engineering-AWS Conference to be held at Hotel Statler, Buffalo, N. Y. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

NEW

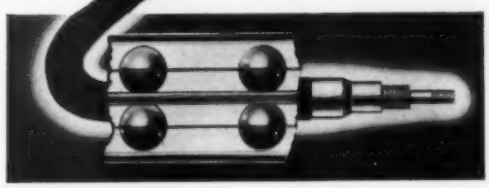
Controlex®

BALL BEARING
PUSH-PULL
REMOTE CONTROL

provides 97% efficiency with heavy load

- needs no lubrication
- minimizes friction
- minimizes backlash

Controlex Remote Control units owe their remarkably efficient operation—97% to a unique and revolutionary design principle: ball bearings provide friction-free movement of a stainless steel blade in flexible tubing. Permits improved layouts of far greater length and curvature, regardless of load. Requires no lubrication; backlash reduced to a minimum. Precision engineered! Check Controlex before you specify any remote control application.



Illustrated folder gives engineering data and full details; write today.

Controlex CORPORATION of AMERICA

Hangar #5, Westchester County Airport, White Plains, N.Y.

—ITEM 169—

MARK TIME reaches into the skies!

. . . Every U. S. Guided Missile Program has used MARK-TIME design and manufacturing experience

Mark-Time design engineers have been called upon to create timing units for almost every guided missile program in the U.S.

These timing mechanisms perform a number of delayed action operations—from activating proximity fuses to the releasing of a recovery parachute.

In jet age aeronautics, as in appliance manufacturing, Mark-Time continues to make Time Control work in the interest of mankind.

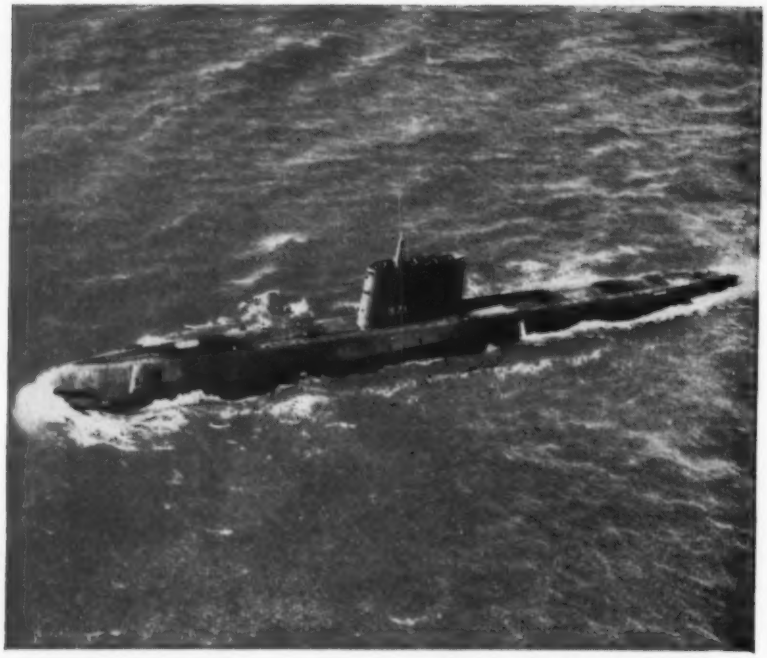
Write, phone or wire for help with your next design problem. Representatives in principal cities in the U. S.

M. H. RHODES, Inc.
Hartford 6, Connecticut

MARK-TIME 25th YEAR

Manufactured and Sold in Canada by:
SPERRY GYROSCOPE OTTAWA Ltd., Ottawa, Ontario, Canada

—ITEM 170—

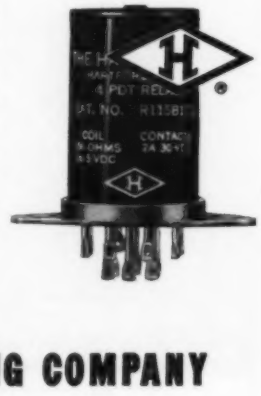


Official U. S. Navy Photograph

'Diamond H' Aircraft-type Relays Go to Sea in the Nautilus

Their reliability proven in such critical land and air applications as guided missiles, jet engine controls and fire control systems, "Diamond H" miniature, hermetically-sealed, aircraft-type relays were chosen by Westinghouse for an important role in the world's first atomic-powered submarine. They're used in the reactor control system of the Nautilus.

Possible performance characteristics of "Diamond H" Series R 4 PDT relays span such broad ranges that the modifications which can be arranged to meet particular sets of requirements are almost endless. They're fully described in Bulletin R250, a copy of which is yours for the asking. Our engineers will gladly work with you to develop a variation for your specific need.



THE HART MANUFACTURING COMPANY

118 Bartholomew Avenue, Hartford 1, Conn.

—ITEM 171—

For More Information Circle Item Number on Yellow Card—page 19

MEN

OF MACHINES

T. E. Roberts Jr. has been named technical director at the Raleigh, N. C. Engineering Laboratories of American Machine & Foundry Co. Dr. Roberts will be concerned with

T. E. Roberts Jr.

basic and advanced research and development work on cigarette machinery and silver-zinc batteries. He joined AMF three years ago as electrical engineer on the staff of the General Engineering Laboratories in Greenwich, Conn. and was section manager of the electrical laboratory there at the time of his new appointment.

National Research Corp., Newton Highlands, Mass., has promoted **Ralph H. Vacca** to manager of the electronics development section and **H. A. Steinherz** to manager of the mechanical development section.

Nicholas J. Hoff, NATO aeronautical consultant and head of the department of aeronautical engineering at the Polytechnic Institute of Brooklyn, has been awarded the Medal of the University of Liege, Belgium, for his "contributions to international co-operation

in aeronautics among NATO nations" and his "services to aeronautical science". The medal was presented to Dr. Hoff at the conclusion of his recent European lecture tour.

George F. Motter's Sons, York, Pa., has announced the appointment of **Emory W. Worthington** as vice president and general manager, with responsibilities including engineering divisions. Mr. Worthington joined the company last June as vice president of engineering.

Ralph W. Rawson has joined Fansteel Metallurgical Corp., North Chicago, Ill., as chief engineer. He will take charge of the company's newly established Centralized Engineering Department.

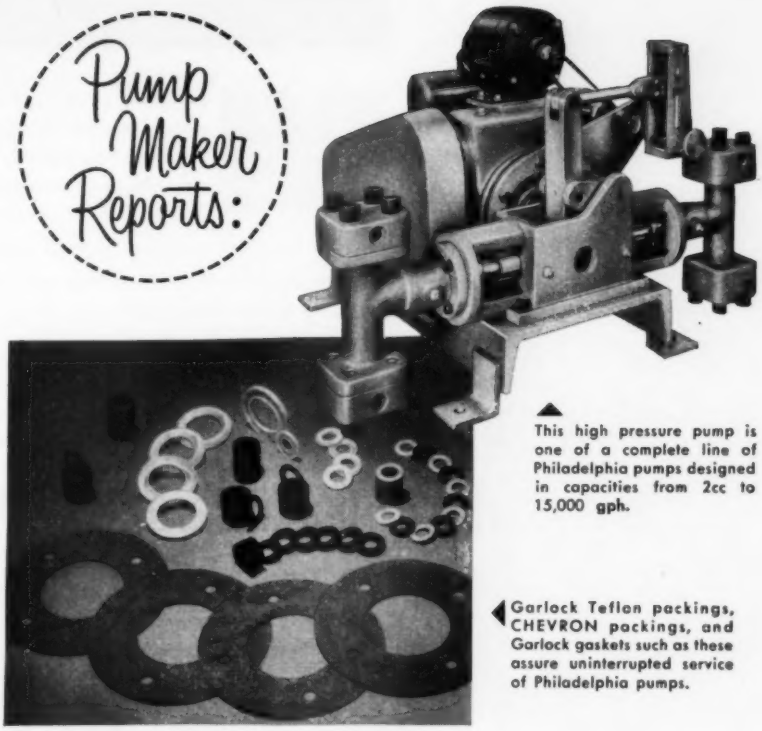
The board of directors of Modern Engraving and Machine Co., Hillside, N. J., recently elected **Alvin W. Keeshan** vice president and chief engineer. He was formerly manager and chief engineer of American Type Founders Inc. He has also been affiliated with the Waymouth Corp. as chief engineer and with Specialties Mfg. Co. as assistant chief engineer.

Alvin W. Keeshan

John Pecek has joined Humphrey Design Co., Cleveland, as chief engineer. His responsibilities will include design, development and fabrication of special automation

(*Continued on Page* 30)

Pump Maker Reports:



▲ This high pressure pump is one of a complete line of Philadelphia pumps designed in capacities from 2cc to 15,000 gph.

◀ Garlock Teflon packings, CHEVRON packings, and Garlock gaskets such as these assure uninterrupted service of Philadelphia pumps.

"GARLOCK *has the answer for ALL our packing and gasketing problems*"

Since its early years, the Philadelphia Pump and Machinery Company, has standardized on Garlock packings and gaskets for its 863 different models of controlled capacity pumps for pressures up to 50,000 psi. The reasons are simple:

1. Only Garlock makes a *complete* line, therefore only Garlock can take complete responsibility for all packing and gasketing problems on all Philadelphia pumps.
2. Garlock's engineering service is unduplicated in the industry. (Every one of Garlock's 125 salesmen is a trained packing expert.) In addition, Garlock maintains an Engineering Service Department staffed with specialists in every phase of packing and gasketing.

Prove for yourself that Garlock has the answer for every packing and gasketing problem. Call your local Garlock representative.

THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N.Y.), Philadelphia, Pittsburgh, Portland (Ore.), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

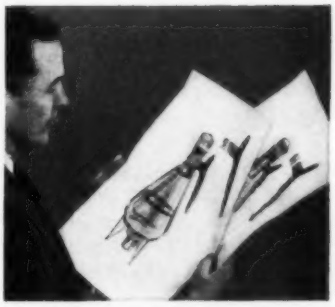
GARLOCK

PACKINGS, GASKETS, OIL SEALS,
MECHANICAL SEALS, RUBBER EXPANSION JOINTS

MONSANTO

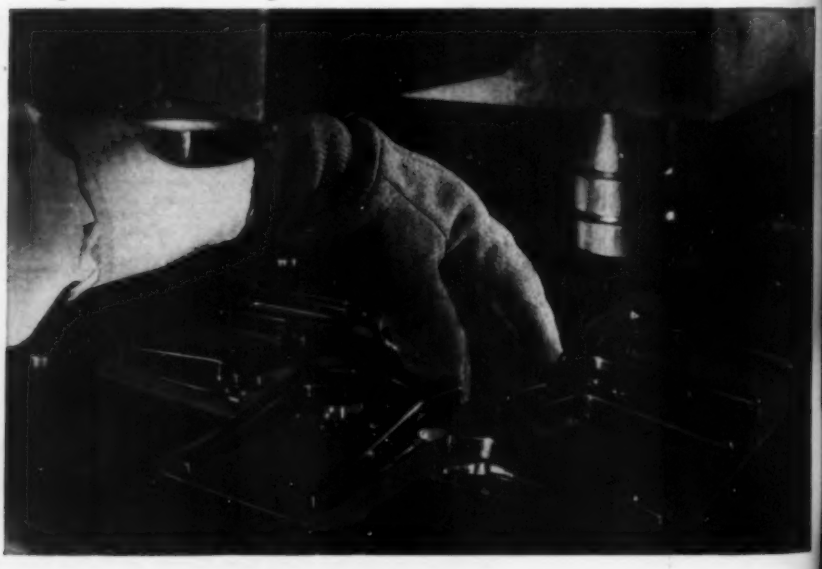
Feverish competition in today's giftware market gives industrial designers many a sleepless night. Forever foremost is the challenge to be first with something new, something better. Read how, by working closely with plastics engineers in the custom molding industry, one of America's leading manufacturers pioneered a winner which utilizes the unique properties offered by plastic materials.

How handles of Resinox phenolic plastic are high-styling Inland Carafes



DESIGN OBJECTIVES. To restyle the conventional coffee carafe with a handle that would both enhance the beauty of the unit and facilitate its pouring. When the Inland Glass Works Division of the Club Aluminum Products Company gave the project to its designers, they were instructed to keep appearance and functionalism uppermost in their plans. Moderate cost was a secondary, but important, consideration.

MATERIAL SPECIFICATION. Designs dictated that the handle be riveted to a 1-inch metal band at the neck of a cone-shaped bottle. Because the center of gravity was extremely low (far below the fulcrum of the handle), a material of outstanding strength was required. Steel was rejected—its high heat absorption made the handle uncomfortable to hold. Wood was rejected—it has a tendency to split with the grain and demanded an additional, expensive finishing step. Selection was narrowed down to a phenolic plastic. This material is both flame- and heat-resistant, has the moldability, inherent color and surface smoothness to permit optimum flexibility in design. (Inland Glass had long been using phenolic plastics with great success on other giftware items.)

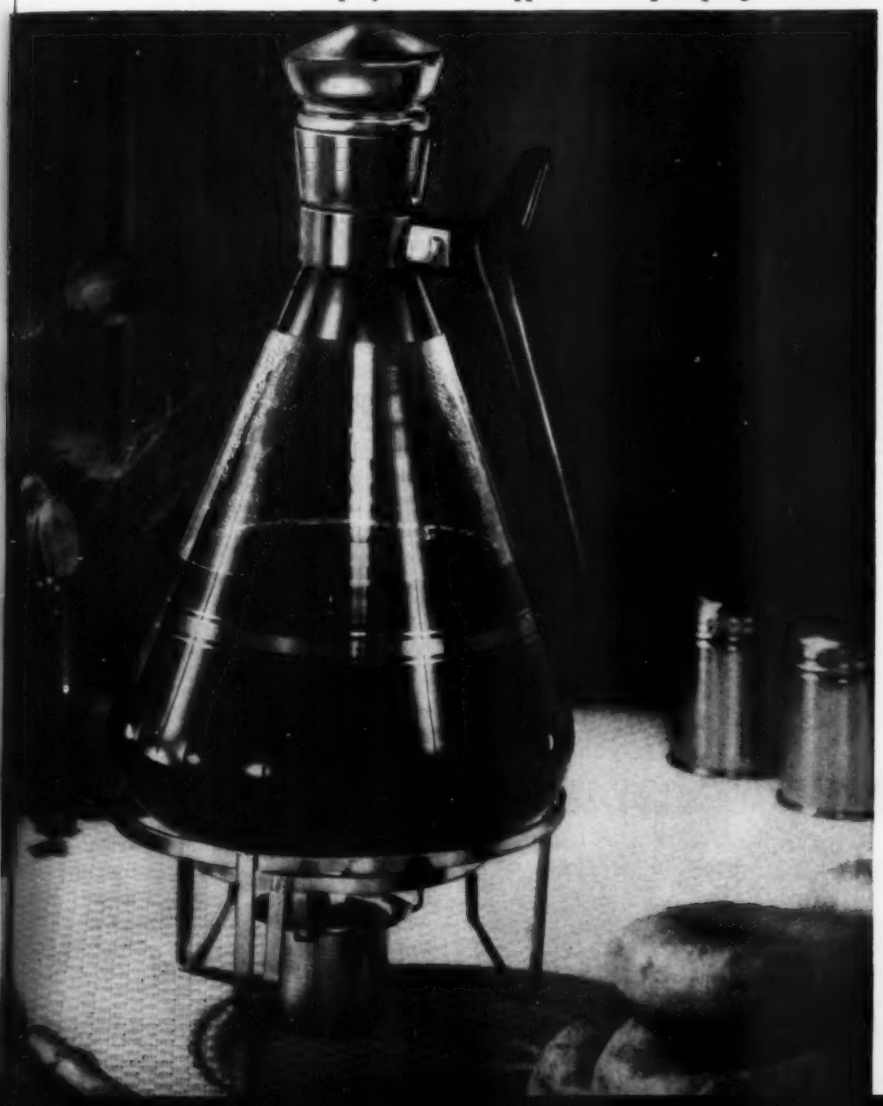


XUM

PRODUCTION ENGINEERING. The custom molding job was awarded to Ackerman Plastic Molding Company, Div. Consolidated Iron-Steel Manufacturing Company of Cleveland, Ohio, whose engineers specified Monsanto's Resinox 1004—a phenol-formaldehyde high-luster plastic with a superior impact strength of .34 foot pounds per inch. The fast flow and curing properties of Resinox 1004 permit non-critical transfer molding at 325° F. Molding powder is preformed into "pills," heated in an electronic oven and placed in the plunger mold. After a 70-second cycle, the "shot" containing 12 molded handles is removed and separated from the runners. The surface of the molded handles has been consistently mirror-smooth. Another vital property of Resinox 1004 compound is strength to resist cracking when metal rivets are inserted into molded-in handle holes and expanded to grip the plastic handle to the metal neck sleeve.

THE FINISHED PRODUCT. Elite Carafes are now smartly serving coffee in more than 800,000 homes. The jet black handles which gracefully parallel the contours of the flask need no finish. Their ebon beauty will never peel or chip—and accentuates the decorative stripings in copper and platinum. Styling like this has made Inland Glass one of the leaders in its field.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Springfield 2, Mass.

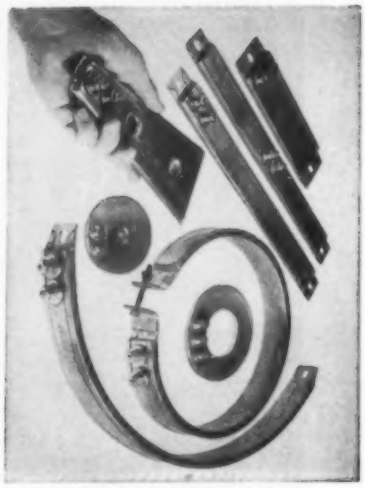


Investigate Monsanto's completely balanced line of phenolic plastic compounds developed for particular applications and sold under the trade name . . .

RESINOX®

MONSANTO

XUM



New manufacturing process improves performance of CHROMALOX Electric Strip Heaters

An improved manufacturing process, combined with a newly developed refractory material, offers you the finest performance in strip heaters. Rugged and long lasting, they are industry's workhorse among heating elements.

So when you use the improved line of Chromalox Electric Strip Heaters, you're assured of even better performance in the heating of platens, dies, kettles, tanks, ovens, air ducts and other applications that require dependable, accurately controlled heat . . . where and when heat is needed.

Let the Chromalox Sales-Engineering staff solve your heating problems—electrically.

Write for your copy of Catalog 50

This data-packed catalog covers the design, uses and prices of the complete line of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get short factual material on many additional applications of electric heat, send for Booklet F1550 "101 Ways to Apply Electric Heat."

Edwin L. Wiegand Company

7575 Thomas Boulevard, Pittsburgh 8, Pa.

EDWIN L. WIEGAND COMPANY
7575 Thomas Boulevard, Pittsburgh 8, Pa.

I would like to have—

☐ a copy of Catalog 50
☐ a copy of "101 Ways"
☐ a Sales-Engineer contact me

Name_____

Company_____

Street_____

City_____ Zone____ State_____

A-4484A

—ITEM 174—

Men of Machines

(*Continued from Page* 27)

lines for feeding, selecting, gaging, sorting and classifying parts. Mr. Pecek was formerly application engineering manager for Cleveland Instrument Co. and also has been associated with Feedall Inc. and the Osborn Mfg. Co.

Harris Products Co., Cleveland, has named **Dan T. Bradley** to the newly created position of vice president in charge of engineering and sales. He joined the company in 1937 as chief engineer and has been engineering vice president since 1949.

Ernest A. Keller has been named director of research by Panellit Inc., Skokie, Ill. Dr. Keller will head a research program which includes development projects in data handling, automation and computer technology.

The Magnavox Co., Ft. Wayne, Ind., has appointed **Lt. Col. John J. Slattery** assistant to the vice president and general manager of the Government and Industrial Div. Col. Slattery was vice president and director of engineering of the Instrument Div. of Sterling Precision Instrument Corp. From 1936 to 1942 he was in charge of radar and electronic countermeasures development at the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. Previous affiliations were with Bell Telephone Laboratories and Radio Corp. of America.

John J. Slattery

Formerly assistant chief engineer, **Charles R. Sutherland** was recently named controller by Reliance Electric Co., Cleveland. At the same time, **Earl C. Barnes** was made assistant chief engineer.

Theodor Buchhold has joined General Electric Co. as a consulting engineer. Dr. Buchhold, who helped to develop the control and guidance systems for several powerful missiles, including the German V-2, will continue his work in the guided missile field, with headquarters in the company's General Engineering Laboratory in Schenectady, N. Y.

Lippmann Engineering Works, Milwaukee, has named **Byron C. Redeen** chief engineer.

James W. Sauber has been appointed chief instrument engineer by Waters Mfg. Inc., Wayland, Mass. **William J. McGrail Jr.** has been named chief potentiometer engineer.

Avco Mfg. Corp., New York, has elected **Arthur R. Kantrowitz** vice president and director of the Avco Research Laboratory, a unit of the advanced development division. Dr. Kantrowitz has taken a leave of absence as professor of aeronautical engineering and engineering physics at Cornell University.

Alwin B. Newton has been made vice president in charge of design and research of Coleman Co. Inc., Wichita, Kans.

Progressive Welder Sales Co., Detroit, has named **William T. Wilbur** chief application engineer. He will have charge of the design of all special application welding equipment.

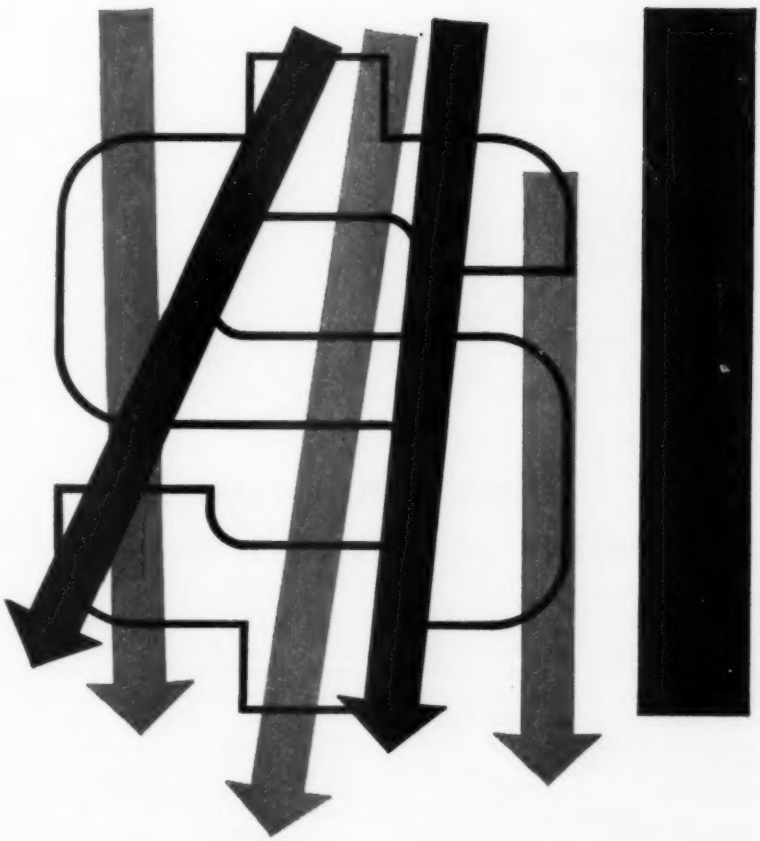
Formerly chief engineer, **Arthur P. Paine** has been named manager of the aircraft division and assistant secretary of Bristol Engineering Corp., subsidiary of Hunter Mfg. Corp., Bristol, Pa.

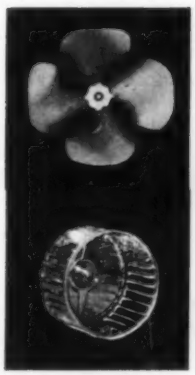
CLOSE TO THE 4 BILLION DOLLAR MARK

Torrington air-impellers are contributing to the quality and saleability of products valued at nearly $4 billion a year. A partial list of product categories:

Room air conditioners
Automobile heaters and air-conditioners
Cooling towers
Commercial coolers
Window ventilators
Kitchen fans
Hassock fans
Electronic cooling devices
Space heaters
Oil burners
Unit heaters

If you have a design or manufacturing problem involving air-impeller equipment, Torrington's industry-wide reputation is your assurance of quality and service.

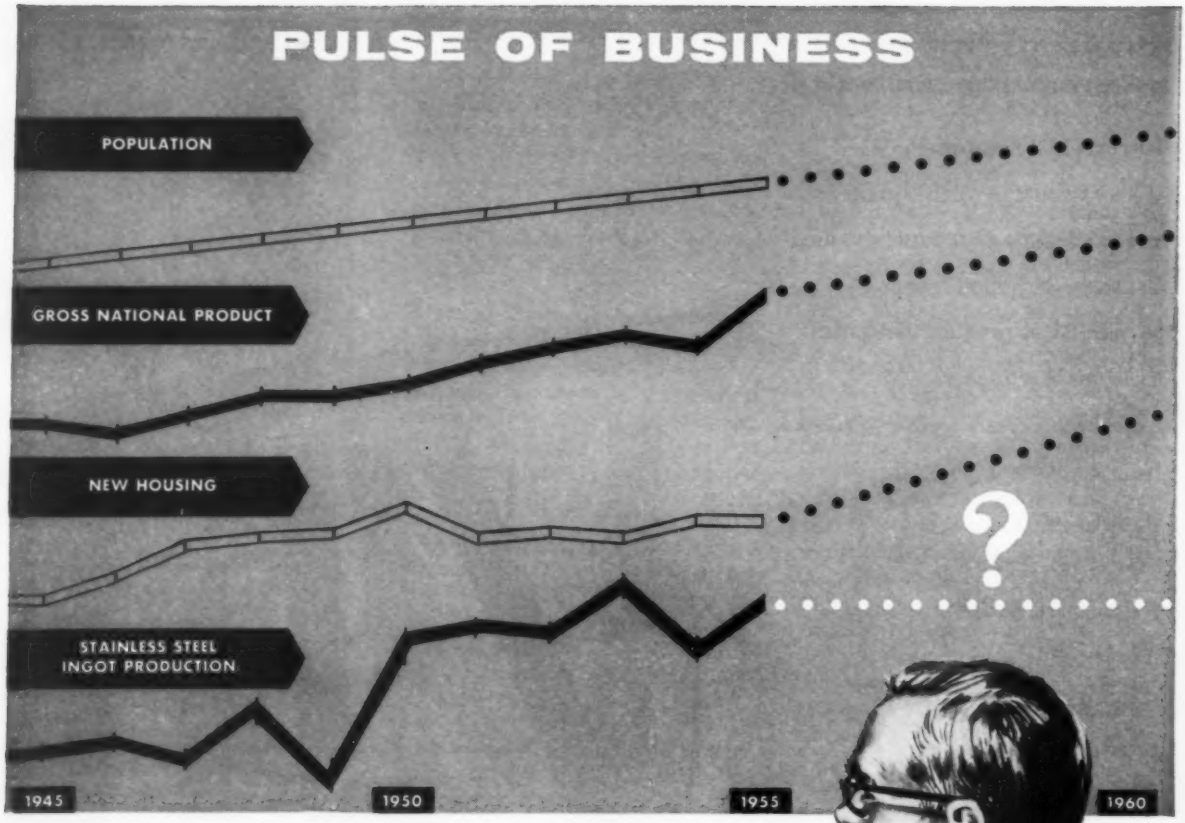




THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

—ITEM 175—
For More Information Circle Item Number on Yellow Card—page 19

XUM



Can you grow with your markets?

As the national economy continues to expand so also will your markets. For you to grow with these markets there must be a corresponding increase in your supply of raw material. Right now, as in the case of stainless steel, this presents a problem.

If stainless steel sheet plays an important part in the manufacture of your product, you are more than likely accustomed to specifying Type 302, 18-8 chrome nickel grade. Due to government stockpiling of critical and strategic nickel, this particular grade is not as readily available as before and no immediate increase in supply can be expected. How then, if you are to increase your participation in this growth, can you overcome your problem?

THERE IS A WAY—another grade of stainless, namely Type 430, *is* readily available. Since it is a straight chromium stainless, it is not affected by the nickel shortage. Type 430 is by no means new and untried as it has been used extensively in strip form by the automotive and other industries. Over 30% of all stainless made in this country is the non-nickel bearing Type 430 produced primarily as strip and not as sheet.

Beside availability, the substantial savings in base price between 430 and the 18-8 grade is also of significant importance in these days of high prices. The amount you are presently spending for your stainless steel supply will buy considerably more stainless in the 430 grade, particularly in our MicroRold sheets.

When applied properly in applications where extreme corrosion resistance is not a factor, Type 430 has all the desired qualities of beauty, strength, corrosion resistance, long life and low maintenance. The steel industry estimates that 50% of all stainless steel sheet applications could satisfactorily use Type 430 as an economical and practical material. If the product is cleaned regularly 430 stainless can be used in any application. Why don't you investigate the possibilities of Type 430 for *your* product?

Washington Steel
Corporation
3-E WOODLAND AVE., WASHINGTON, PA.

Send for your copy, "Care and Use of 430 Stainless"

—ITEM 176—
For More Information Circle Item Number on Yellow Card—page 19

Another Example of

VICKERS®

HYDRAULICS

in Automation

Ex-Cell-O Precision Cylinder Boring Machines shown below are finish-boring V-8 engine blocks. Like so many other high-production machines, these make generous use of hydraulics.

In addition to the advantages inherent in hydraulic control, Vickers Hydraulics gives you the benefits of a nation-wide company-operated field engineering and service organization to assure correct application and operation with least maintenance. Vickers has the complete line of hydraulic equipment necessary to take undivided system responsibility . . . to eliminate any risk of incompatibility of hydraulic components.

The Vickers Application Engineer near you will be glad to demonstrate the many benefits you can obtain by using Vickers Hydraulics. Write for a copy of Catalog 5002B.

VICKERS INCORPORATED

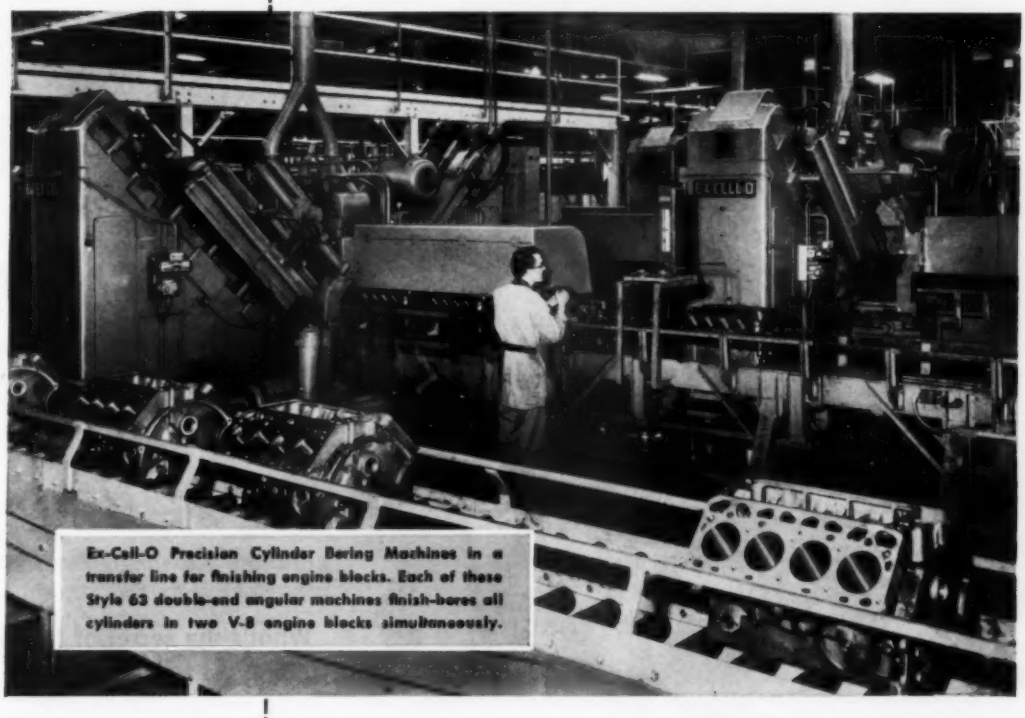
DIVISION OF SPERRY RAND CORPORATION

1430 **OAKMAN BLVD. • DETROIT 32, MICH.**

Application Engineering Offices: **• ATLANTA • CHICAGO • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS TULSA • WASHINGTON • WORCESTER**

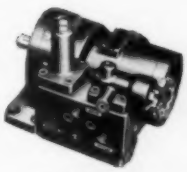
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

Engineers and Builders of Oil Hydraulic Equipment Since 1921



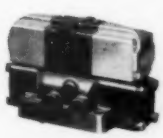
Ex-Cell-O Precision Cylinder Boring Machines in a transfer line for finishing engine blocks. Each of these Style 63 double-end angular machines finish-bores all cylinders in two V-8 engine blocks simultaneously.

Representative VICKERS Units Used on Ex-Cell-O Precision Cylinder Boring Machines



Two-Pressure Pump

Insures lower maintenance cost and saves horsepower and heat in two-pressure hydraulic circuit. Automatically provides high volume at low pressure and low volume at high pressure.



Solenoid Controlled Pilot Operated 4-Way Valve

Compact and versatile "sandwich" construction. Gasket mounting simplifies installation and overhaul . . . also minimizes piping.

Traverse and Feed Cycle Control Panel

Maintains smooth and constant preset feed rate regardless of fluctuations in cutting tool resistance or hydraulic pressure.

7350

—ITEM 177—

For More Information Circle Item Number on Yellow Card—page 19

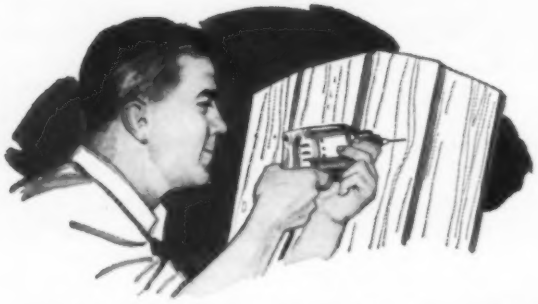
XUM

Before buffing. Note the high quality surfaces on these raw Doehler-Jarvis die castings for Black and Decker's new ¼" Utility Drill.

After buffing. Front photo shows mirror finish attained.

How Doehler-Jarvis helps *Black & Decker's* "do-it-yourself" family make merchandising history

Doehler-Jarvis die casts power tool that buff to a mirror finish in



Millions of "do-it-yourselfers" got their start with a Black and Decker power tool.

What makes people reach for a B & D tool? ...not only men, but women, too?

B & D says, "Good looks, good design, good quality, good price!"

Doehler-Jarvis die castings help Black and Decker achieve all four.

That eye-catching finish, for example. It's not chrome. It's "as-cast" aluminum, buffed to mirror brightness in *one* operation. No pre-grinding. No roughening. No grease wheeling. Not even a final buffing after assembly.

What's the secret of this quality finish?

Some people just point to a raw Doehler-Jarvis casting. "Look at that 'Hardware' surface," they say. "Not a dent. Not a blemish. Not a flow mark. It's even hard to tell where parting line and flash have been removed."

And certainly Doehler-Jarvis does give Black and Decker a casting they can work with. But you should see Black and Decker's buffing set-up. It's fully automatic, fully controlled. Air conditioned, without a speck of dust. Few concerns go as far as B & D to insure high quality buffing.

Reality lies somewhere in between

Achievements like this are to be expected

housings one operation

when a closely knit relationship develops between engineers of two companies over many years of product development.

Hardly a Black and Decker tool has not benefited in one way or another from this fruitful relationship. From it has come lighter weight, higher precision, increased strength, simplified and lower cost production, many performance improvements. And Black and Decker takes full advantage of the flexibility of die castings to provide extra sales features and aid economy.

Maybe this is the time for you to do as companies like Black and Decker, Singer, AMF, Underwood, York, and many another have done...time to initiate a profitable business and engineering relationship based on the use of Doehler-Jarvis die castings.

Doehler-Jarvis Division

of

National Lead Company

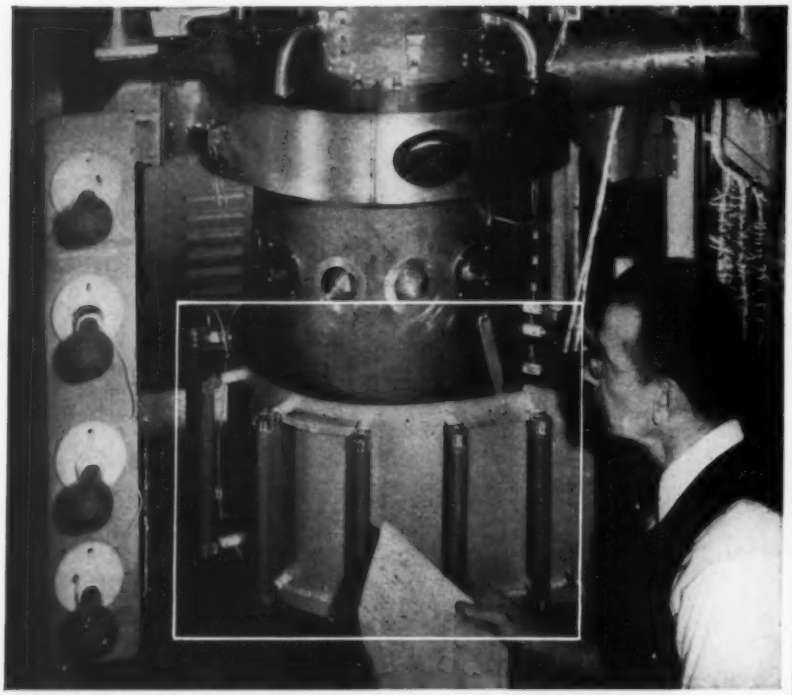
General Offices: Toledo 1, Ohio

—ITEM 178—
For More Information Circle Item Number on Yellow Card—page 19

(Advertisement)

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components



BIG MOON RADAR undergoing tests. Ward Leonard resistors—like those in foreground—help this gear stay on the air—or, rather, on space.

New moon radar to explore outer space

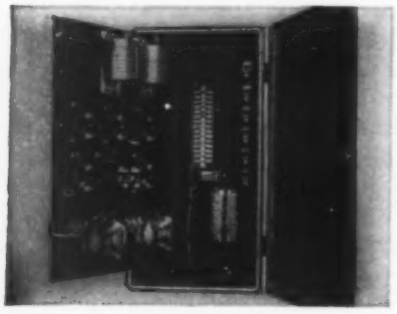
The U.S. Army Signal Corps hasn't got a transmitter in outer space—yet.

So, for their continuing studies of radio wave propagation in space and the upper atmosphere, they bounce radio waves from their new high-powered radar, Diana, off the moon and planets and study the return pulse.

Designed and built by Radio Engineering Laboratories of Long Island City, N. Y., the new radar transmitter puts out 50 kilowatts, continuous wave, and may be pulse modulated at various pulse widths and repetition rates. Receiver gain is 170-db at better than 3-db noise figure.

Throughout the equipment, high-stability Ward Leonard resistors, like the big Vitrohm resistors shown above, do duty as high-voltage bleeders, surge and current limiting resistors, and protective meter shunts in high-voltage circuits.

You'll find Ward Leonard Vitrohm resistors completely described in our 64-page Catalog No. 15, together with nomographs and charts to help select them. Write for your copy today.



Relays mastermind traffic lights

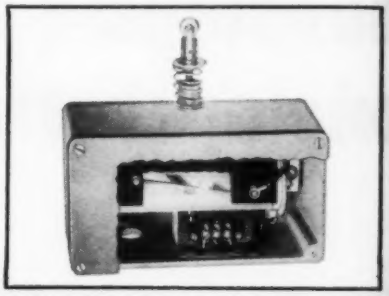
Sun, rain, sleet, snow, and continuous 24-hour-a-day duty is the lot of this master traffic light controller. Four dependable Ward Leonard relays select automatic timing cycles. Two more relays allow remote control of off-duty flashing amber signals and signal shut-down. Learn more about these rugged relays in Ward Leonard Bulletin No. 110.

Photo courtesy Crouse-Hinds Co.

SHE'S CHECKING CHART RECORD from X-ray spectrometer in Ward Leonard's test lab.

Plant X-ray speeds quality control and helps catch crooks

X-ray diffractometer and spectrometer tests insure high quality and uniformity of both raw materials and fabricated components at Ward Leonard. These instruments check crystal structure in ceramics, magnetic amplifier cores, contact metal, and resistance wire. In off hours, they help the Mount Vernon Police and Fire Department put the finger on crooks and arsonists.



AUTOMATION FOR MACHINE TOOLS is simplified by this precision control potentiometer.

Control for machine tools

Accurate electronic control component for cutting tools, winders and processing machine drives is provided by this compact, precision potentiometer.

A half-inch plunger movement drives the metal alloy contact across the special resistance element. Enclosure is compact; calibration is permanent. Standard resistance—10,000 ohms; up to 25,000 ohms on special order. Write for Bulletin 68. 63

WARD LEONARD ELECTRIC COMPANY
50 SOUTH ST., MOUNT VERNON, N. Y.

Result-Engineered Controls Since 1892

RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS

XUM

PHILLIPS CROSS RECESSED HEAD SCREWS

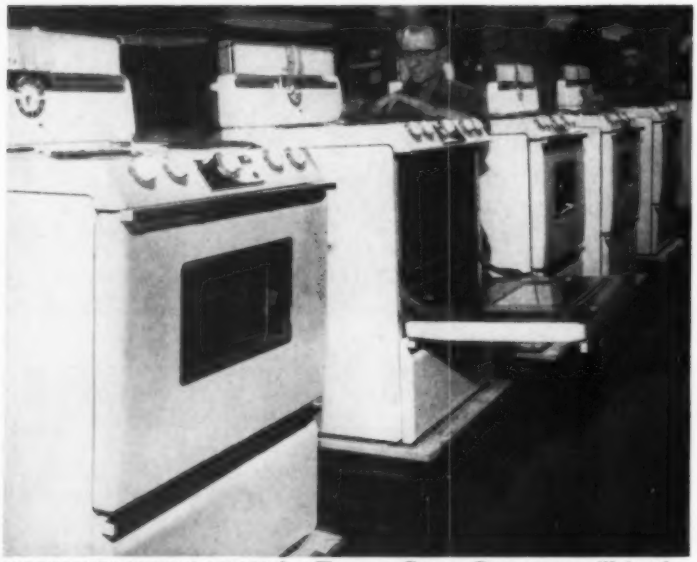
These fasteners of today — and of the future — are manufactured by the companies listed on the fourth page of this folder.

X marks the spot . . . the mark of extra quality

XUM

Why Users Praise PHILLIPS *Cross-Recessed-Head* SCREWS

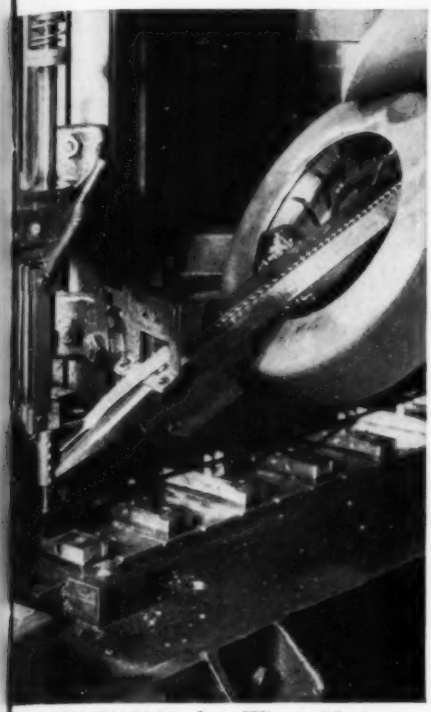
CHROME IRON by Dominion Electric has many "blind" locations for assembly screws. W. A. Reis, production engineer, says, "Phillips screws permit us to design appliances which permit the screw to be installed at a difficult angle without slowing production or marring work."



MODERN TAPPAN RANGES by Tappan Stove Company will in the future all be assembled with Phillips screws. Says a Tappan official, "I don't know of a single case where they have failed us . . . I can't say enough about their fastening qualities."

DISHWASHER by Apex Electrical Manufacturing Company is assembled with Phillips screws as fasteners. William A. Haverlock, superintendent, says, "They're tighter and there's less fear of damage to screw, bit or enamel due to driver slippage. They hold better, too, over prolonged use."

XUM



"PLUGMOLD" by Wiremold is assembled on this automatic machine. Eugene Pitcher, plant engineer, says, "Without self-centering Phillips screws we simply would not be able to utilize this automatic assembly method."

"BRAIN" of an Otis elevator calls for nearly 2000 screws on switches. S. H. Sanford, Otis consulting engineer, says, "We are so sure of the superiority of Phillips screws for the purpose that we incorporated them in all our engineering drawings."

SCREENING AUDIOMETER by Sonotone uses Phillips screws to anchor the calibration indicator panel. P. R. Werner, engineer in charge, says their use eliminates costly and time-consuming recalibration of the dials. "We use them on panels, doors and hinges, too."

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY... AND OF THE FUTURE

X *marks the spot ... the mark of extra quality*

Pledged to highest standards...

The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

Look to them for **X***-tra quality Phillips Cross-Recessed-Head Screws*

AMERICAN SCREW COMPANY
Willimantic, Connecticut

ATLANTIC SCREW WORKS, INC.
85 Charter Oak Avenue,
Hartford 1, Connecticut

THE BLAKE & JOHNSON CO.
Waterville 14, Connecticut

CENTRAL SCREW COMPANY
3501 Shields Avenue,
Chicago 9, Illinois

CONTINENTAL SCREW COMPANY
New Bedford, Massachusetts

ELCO TOOL AND SCREW CORPORATION
Rockford, Illinois

GREAT LAKES SCREW CORP.
13631-51 So. Halsted Street,
Chicago 27, Illinois

THE H. M. HARPER COMPANY
Morton Grove, Illinois

THE LAMSON & SESSIONS COMPANY
1971 West 85th Street,
Cleveland 2, Ohio

NATIONAL LOCK COMPANY
Rockford, Illinois

THE NATIONAL SCREW & MANUFACTURING COMPANY
Cleveland 4, Ohio
Los Angeles 22, Calif.

PARKER-KALON Division
General American Transportation Corporation
Clifton, New Jersey

PHEOLL MANUFACTURING CO.
5700 Roosevelt Road,
Chicago 50, Illinois

SCOVILL MANUFACTURING COMPANY
Waterville 14, Connecticut

SHAKEPROOF Division Illinois Tool Works
2501 North Keeler Avenue,
Chicago 39, Illinois

THE SOUTHINGTON HDWE. MFG. COMPANY
Southington, Connecticut

STERLING BOLT COMPANY
363-405 West Erie Street,
Chicago 10, Illinois

WALES-BEECH CORPORATION
2240 Fifteenth Street,
Rockford, Illinois

4.6.1 Printed in U.S.A.

Members Screw Research Association

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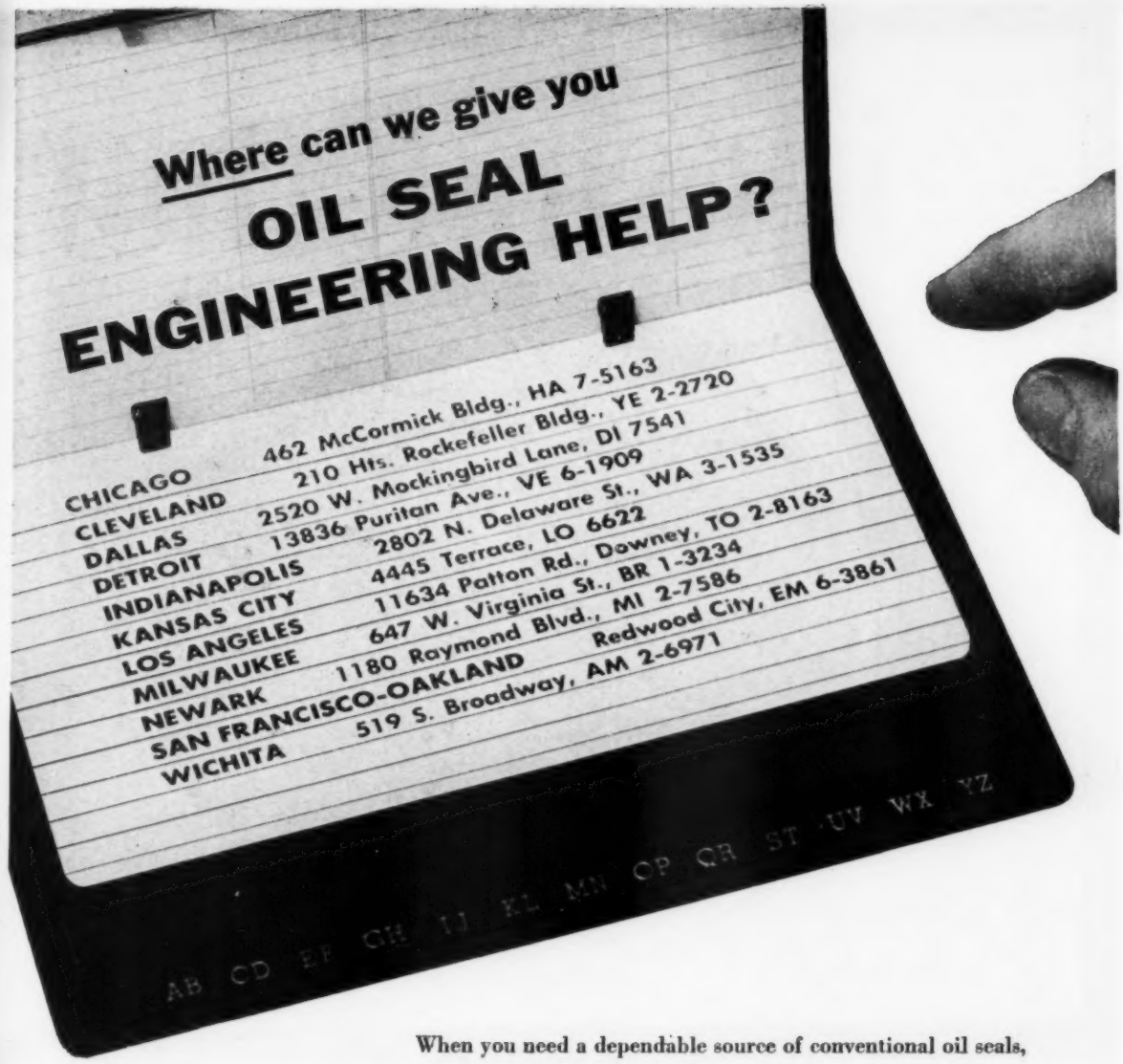

Where can we give you
OIL SEAL
ENGINEERING HELP?
CHICAGO 462 McCormick Bldg., HA 7-5163
CLEVELAND 210 Hts. Rockefeller Bldg., YE 2-2720
DALLAS 2520 W. Mockingbird Lane, DI 7541
DETROIT 13836 Puritan Ave., VE 6-1909
INDIANAPOLIS 2802 N. Delaware St., WA 3-1535
KANSAS CITY 4445 Terrace, LO 6622
LOS ANGELES 11634 Patton Rd., Downey, TO 2-8163
MILWAUKEE 647 W. Virginia St., BR 1-3234
NEWARK 1180 Raymond Blvd., MI 2-7586
SAN FRANCISCO-OAKLAND Redwood City, EM 6-3861
WICHITA 519 S. Broadway, AM 2-6971
AB CD EF GH IJ KL MN OP QR ST UV WX YZ

When you need a dependable source of conventional oil seals, or engineering help on new seals to meet unique conditions, call your National Oil Seal Applications Engineer. He's a specialist in seals, factory trained and a veteran at his business. Whether your seals can be shipped from stock, made from existing tools, or require new engineering, he'll give you a fast, accurate and realistic answer.

Your National Applications Engineer is backed by the productive capability of four big NMB plants, and 35 years of oil seal specialization. Call him while your new design is still on the drafting board—the best time to specify seals. His telephone number and address are listed above.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS
Product of the world's largest exclusive manufacturer of oil seals

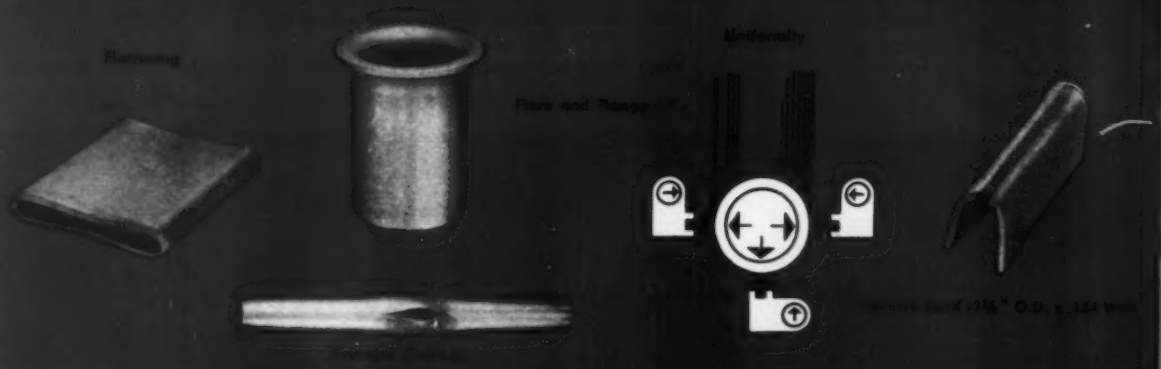
NATIONAL MOTOR BEARING CO., INC.
Plants at Van Wert, Ohio, Redwood City, Downey and Long Beach, Calif.
General Offices: Redwood City

3676

XUM

it's smoother,

CONTOUR-WELD PIPE ... BEST BY ANY TEST YOU CAN NAME



stronger

...new Contour-Welded Stainless pipe completely free of bead or undercut

You can't even *feel* the weld on new TRENTWELD stainless pipe and tubing, thanks to the new, exclusive *Contour-Welding** process.

Here's How It Works *Contour-Welding*, shown in detail below, is an entirely new and patented process of making welded pipe and tubing. It results in a weld that conforms to the exact contour of the pipe. And the weld is so smooth you can't even feel it. There's never a hint of weld-bead or undercut, where corrosion or erosion can get started.

New TRENTWELD Is Better Than Ever Now you get all of the proved-best features of TRENTWELD – uniform stainless strip...wall thickness that never varies throughout the pipe or tube... curvature that's always 'in-round' – *plus* new *Contour-Welding* which extends this uniformity to the weld zone itself. What's more, Trent's superior cold-working facilities mean an even stronger pipe with smoother flared or flanged ends. Result: New TRENTWELD outperforms any other pipe, welded or not.

Put *Contour-Welded* pipe or tubing through any test you like. But the best test is your next job, especially if it's a tough one like a high-pressure hydraulic system... a line carrying corrosive chemicals . . . or high-velocity system. New TRENTWELD comes in any size or gage... and in most grades, including Hastelloy, Zirconium, Zircoloy, Titanium and 19-9-DL. You can use it with confidence – it's a product of Trent, tube mill *specialists*.

*Contour-Weld is the trade mark of the Trent Tube Company for its process of welding pipe and tubing which is protected under U.S. Patent 2,716,692.

Why Trent's Exclusive *Contour-Weld* Process Means Smoother Welds...

Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the I.D. surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

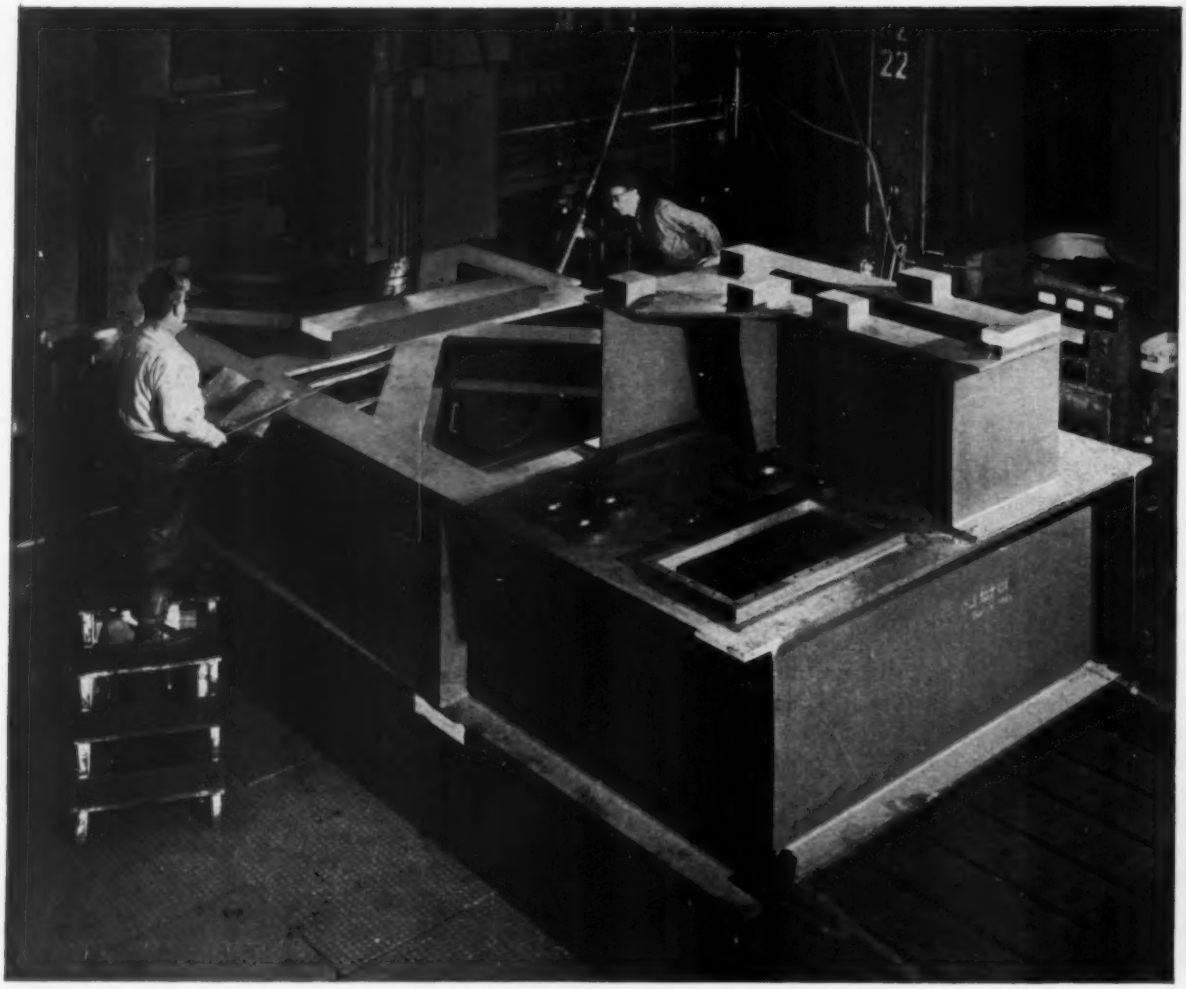
TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

—ITEM 182—

XUM



Finishing touch to a big job

Careful milling in one of our machine shops was the last step—the finishing touch—in making this welded gas-turbine bed frame for Westinghouse Electric Corporation. It is one of twelve which will be shipped to the Venezuelan oil fields, where 8000-hp Westinghouse gas turbines will be mounted on them. These turbines will be used in injecting compressed natural gas into oil wells, thereby recovering additional petroleum while conserving the gas.

Fabricated from structural and plate components, each bed frame measures approximately 35 ft long by 9 ft wide and nearly 6 ft deep. Welding was mainly manual, and a tricky job it was, with each frame including an integral 1000-gal oil reservoir. Other operations included stress-relieving, shot-blasting, testing of the reservoir, and machining as shown above.

Custom weldments like these impose more than ordinary demands on the fabricator. Unusually complete facilities are necessary, as well as thoroughly qualified and experienced personnel. We believe you will find that Bethlehem fills the bill in all these respects.

So, if you have a weldment—any type, any size—in the planning stages, please call on us. The nearest Bethlehem sales office will gladly give you further information.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation.
Export Distributor: Bethlehem Steel Export Corporation

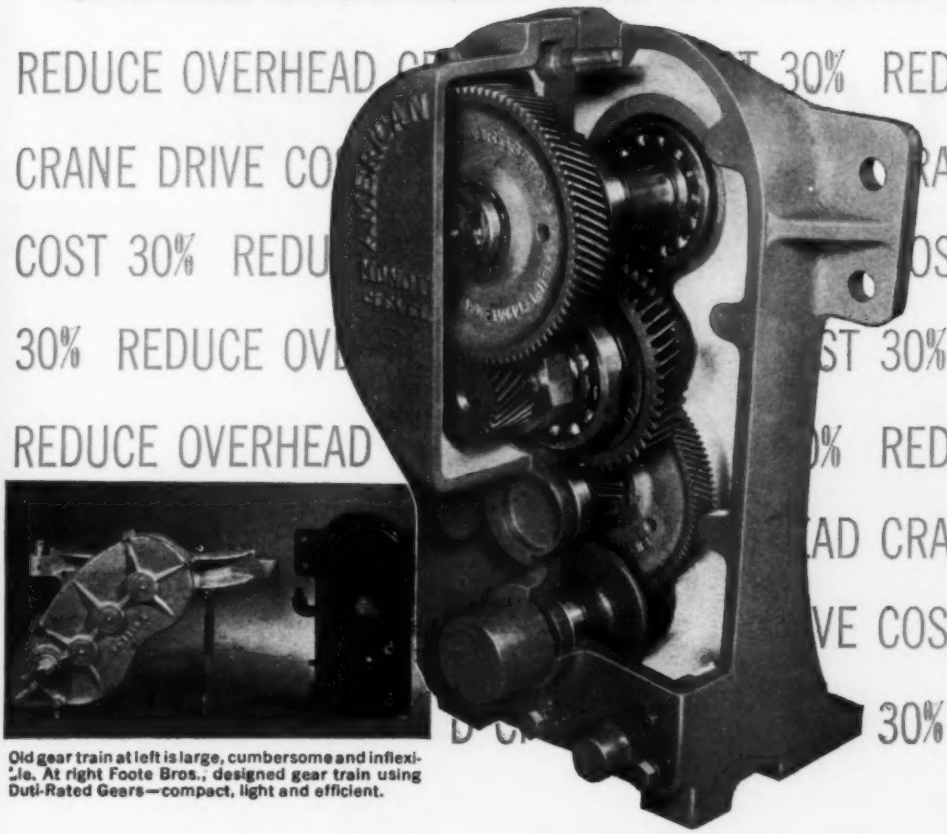
BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 183—
For More Information Circle Item Number on Yellow Card—page 19

Duti-Rated Lifetime Gears

REDUCE OVERHEAD CRANE DRIVE COST 30%



Old gear train at left is large, cumbersome and inflexible. At right Foote Bros., designed gear train using Duti-Rated Gears—compact, light and efficient.

100% more capacity - 25% less weight - 28% less size

Ordinary commercial gearing in the traversing drive for an overhead, traveling crane system was bulky and had to be set at a space wasting 45° angle to save head room. Foote Bros. designed a special transmission system using Lifetime Duti-Rated Gears, permitting the application of smaller gears for the same capacity, allowing shorter center distances and a much more compactly designed drive.

The savings in space not only improved the design and performance of the overhead crane but also life expectancy. Maintenance requirements were greatly reduced. An outstanding feature of the new drive was that the Duti-Rated Gears could be interchanged on the same centers to change the ratios . . . allowing various speeds, fast and slow, for traversing.

This is only one example of what Duti-Rated Gears are doing in industry today. Extra gear capacity in less space . . . with longer life and lower costs . . . could be important to you, too. Call Foote Bros. today and learn all the advantages of Duti-Rated Lifetime Gearing . . . pre-engineered as standard or designed for your application. *FREE! Foote Bros. Engineering Manual "Duti-Rated Lifetime Gearing". Write for your copy today!*

This trademark stands for the finest industrial gearing made!

FOOTE BROS. Duti-Rated LIFETIME GEARING

T.M. Reg. U.S. Pat. Off.

FOOTE BROS.

Better Power Transmission Through Better Gears

Foote Bros. Gear and Machine Corporation

4545 South Western Blvd., Dept. O, Chicago 9, Ill.

—ITEM 184—

Here it is . . . !

THE NEW "48-FRAME" THAT GIVES YOU Century

MOTOR DESIGN
INDUSTRIAL QUALITY

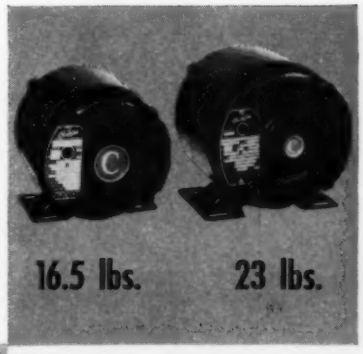
Everything you asked for and more. Smaller, yes . . . and better, too. Here is traditional Century dependability, smooth-running and quietness under load . . . now skillfully engineered into the compact new "48-Frame" design.

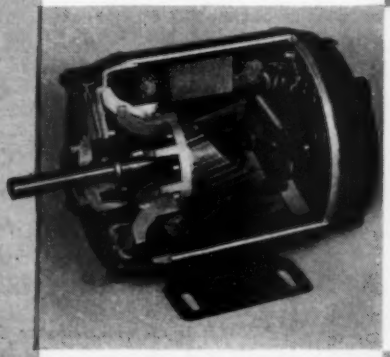
These great new Century "Industrial Quality" motors are now available in sizes from 1/20 to 1/3 H.P. . . . developed specially for industrial users.

SEE A SAMPLE of the New Century "48-Frame" motor . . . test one in your plant. Your Century representative will be glad to show you a graphic point-by-point comparison to answer any specific questions you might have. Let him show you how the smaller, lighter and *better* new Century "48-Frame" design gives you true *industrial* quality. Call or write your nearby Century District Sales Office or Authorized Distributor.

We Invite Your Comparison of . . .

engineering—Weight savings up to one-third are made possible without "skimping" on the vital "active materials," simply by eliminating dead weight and using new materials. The result is smaller-diameter motors that are not merely "just as good" but actually superior to the famous Century "56-Frame."





compare design—For time-saving maintenance, "GITS"-type oilers for sleeve bearings are placed high on the end-brackets, allowing easy oiling from either end of the motor . . . cluster-type integrally cast fan at the rear end of the rotor draws a steady stream of cooling air over the coilheads . . . "Square" stator iron permits air to pass between the core and shell, cooling the whole width.

compare materials—Genuine bonded "MYLAR" slot insulation is used . . . wound cores are dipped and baked in thermosetting insulating varnish . . . GLASTIC high arc resistance switch-mounting plate . . . light and strong, *stress-relieved* pressure-cast aluminum end-brackets, which machine true and *stay* true.

-55

Performance Rated®
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

—ITEM 185—

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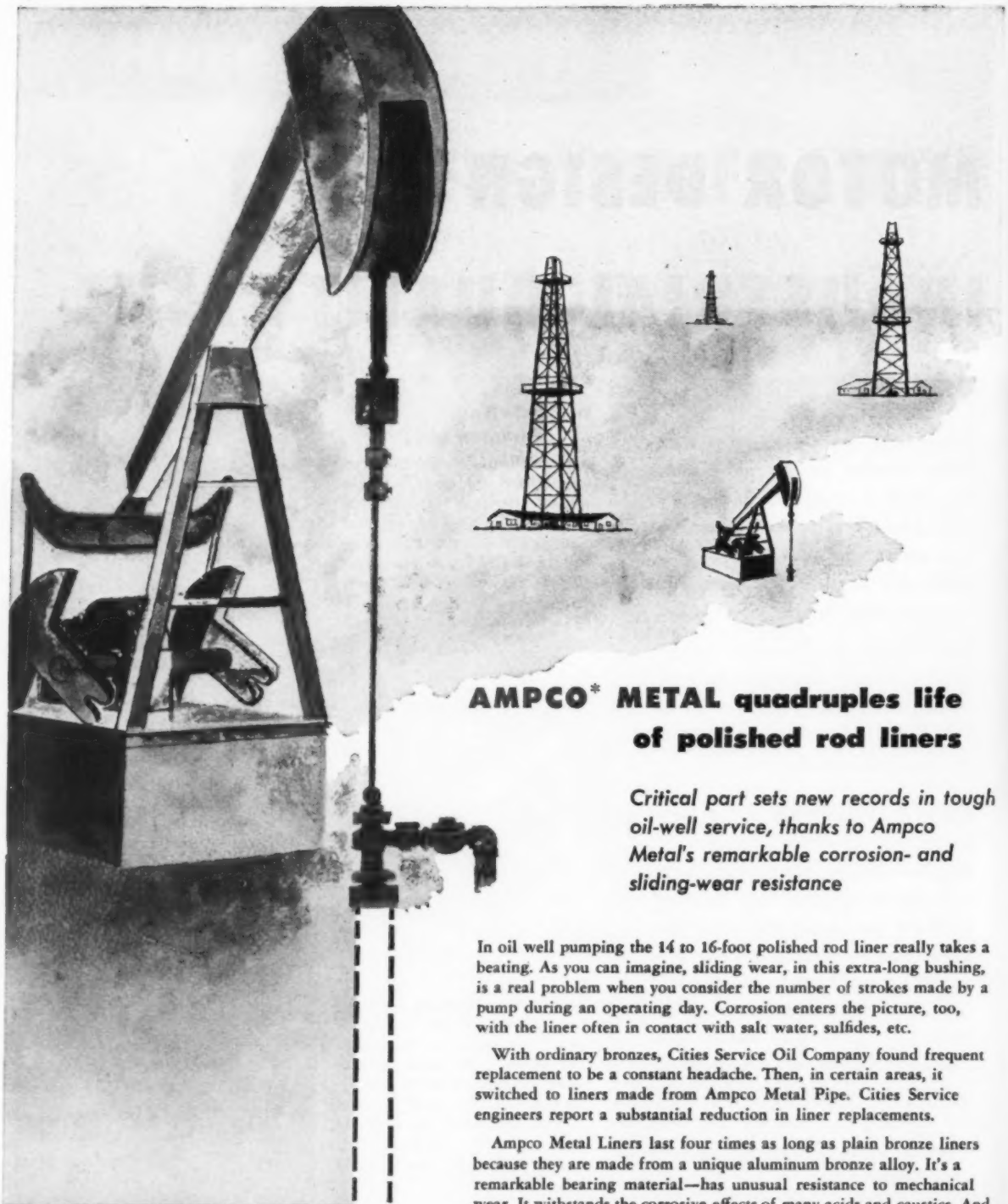


AMPCO* METAL quadruples life of polished rod liners

Critical part sets new records in tough oil-well service, thanks to Ampco Metal's remarkable corrosion- and sliding-wear resistance

In oil well pumping the 14 to 16-foot polished rod liner really takes a beating. As you can imagine, sliding wear, in this extra-long bushing, is a real problem when you consider the number of strokes made by a pump during an operating day. Corrosion enters the picture, too, with the liner often in contact with salt water, sulfides, etc.

With ordinary bronzes, Cities Service Oil Company found frequent replacement to be a constant headache. Then, in certain areas, it switched to liners made from Ampco Metal Pipe. Cities Service engineers report a substantial reduction in liner replacements.

Ampco Metal Liners last four times as long as plain bronze liners because they are made from a unique aluminum bronze alloy. It's a remarkable bearing material—has unusual resistance to mechanical wear. It withstands the corrosive effects of many acids and caustics. And when used as pipe it combats erosion from solids held in suspension.

Ampco pipe and tubing is available in all sizes, along with a complete line of flanges and fittings. Send coupon today for full information.

*Reg. U. S. Pat. Off.

AMPCO METAL, INC. D-45
Dept. MD-3, Milwaukee 46, Wisconsin

I'm interested in knowing more about the wear- and corrosion-resistant properties of Ampco Metal. Please send me complete information.

Name..... Title.....

Company.....

Company Address.....

City..... (.....) State.....

AMPCO ® **AMPCO METAL, INC.**

Sole Producer of Genuine Ampco Metal

Main Office and Plant
Milwaukee 46, Wisconsin
West Coast Plant
Burbank, California

Left—Allen-Bradley Size 7 solenoid contactor used in large solenoid starters.

Below—Allen-Bradley Size 7 solenoid starter with overload relays in NEMA Type 1 general purpose, floor mounted enclosure.

ALLEN-BRADLEY SOLENOID STARTERS USE DOUBLE BREAK, SILVER ALLOY CONTACTS THROUGHOUT!

Eight Sizes up to 300 hp, 220 v; 600 hp, 440-550 v.

Bulletin 709 solenoid starters shown here in Sizes 0 to 6—all equipped with accurate and reliable overload relays.

All starter manufacturers use the solenoid construction and double break, silver alloy contacts for their lower starter ratings, because experience has proved this construction superior to any other. Therefore, wouldn't this experience repeat itself with the higher rated starters?

Allen-Bradley has found this to be absolutely true. Its starters of high hp rating are regularly establishing new standards of starter performance. As you go from size to size, the operating characteristics remain the same—you get trouble-free, long-life performance.

Standardize on Bulletin 709 solenoid starters—they are Tops in Quality!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

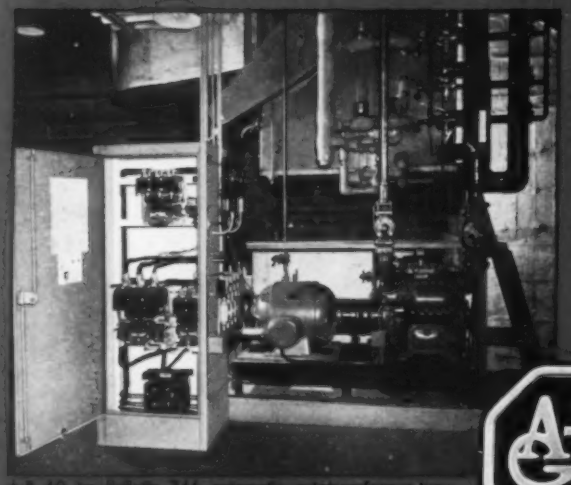
3-56-MR

ALLEN-BRADLEY

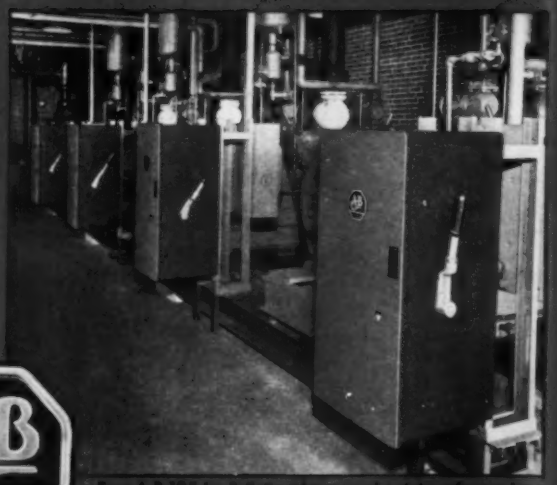
SOLENOID STARTERS

QUALITY

XUM

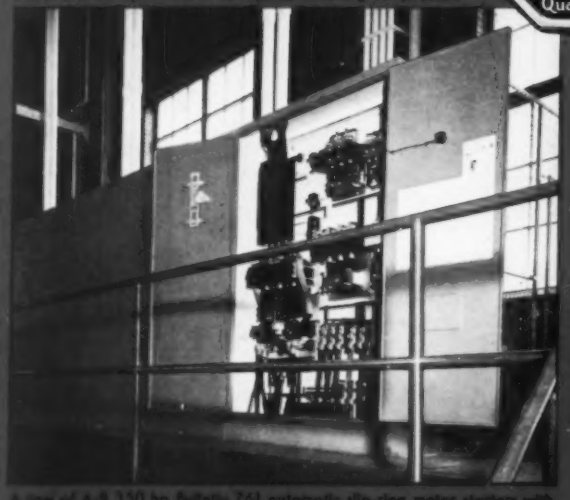


A-B 60 hp bulletin 746 automatic autotransformer-type motor starter used with a York air-conditioning compressor.



Four A-B 125 hp bulletin 646 manual autotransformer-type motor starters used with refrigeration compressors in a dairy.

A-B Quality



A row of A-B 350 hp Bulletin 761 automatic slip-ring motor starters with

Allen-Bradley Bulletin 798 multi-unit control center used with motors

ALLEN-BRADLEY STARTERS FOR LARGE A-C MOTORS ARE AS POPULAR AS THE BULLETIN 709 SIZE 1 FOR SMALL MOTORS

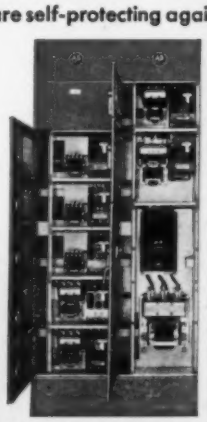
Allen-Bradley manual and automatic starters for large squirrel-cage, slip-ring, and synchronous motors—both high and low voltage—have earned the same reputation for "Quality" for which the lower ratings are known. Every operating requirement can be satisfied, either with individual units or as sections of a multi-unit control center.

Allen-Bradley high voltage starters are rated up to 1500 hp with voltages ranging from 2000 to 4600 volts. The high voltage, synchronous motor starters are self-protecting against short circuits up to 250,000 kva on 2501-4600 volts, 3 phase, 60 cycles. Oil or air break switching available. Please write for the Handy Catalog.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

A-B automatic autotransformer, reduced voltage starter with cabinet open to show control panel.

ALLEN-BRADLEY
SOLENOID STARTERS
QUALITY



A-B multi-unit control center with compartment doors open to show various types of motor controls.

3-56-MR

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(Advertisement)

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

What's the right torque for bolts?

This is one of the toughest questions we're asked. Too many variable conditions. But the following may help.

The bolt takes two stresses during wrenching: (1) Torsion, (2) Tension. Tension is what you want. Torsion is the necessary evil due to friction. Probably 90% of applied torque goes to overcome friction.

With the friction factor changed by lubrication, plating, etc., the torque needed to produce a given tension is hard to predict. However, a useful empirical formula exists for *normal* friction conditions.

Inch-lbs. Torque = 0.2 x bolt diameter x bolt tension

Many tests show that the 0.2 torque coefficient is approximately constant for the usual friction conditions, for all diameters, and for both coarse and fine thread. Average deviation is about 7%. But when are conditions *"normal"?* The only *sure* way to check torque is to set up a pilot assembly and try it out.

In pilot testing for rigid joints, tighten a few bolts with torque wrench to failure, and then set torque at 75% of that load; or even at yield strength, since torsion component vanishes leaving bolt under tension only, which is well below ultimate strength.

We've worked up curves giving suggested torques for various size bolts. Send for a copy.

How to make a stronger joint

From research on structural steel joined with high strength bolts come facts applicable to *products:*

These bolts can be torqued to high tension for a large clamping force on joined members. Resultant friction overcomes shearing forces and prevents slippage. The higher compressive forces also protect bolt holes from fatigue cracks. Moreover, the tighter the bolt, the less chance for loosening, and the less risk of bolt fatigue due to dynamic loading.

High strength bolts are stronger in shear, too. In recent tests, rivets and "soft" bolts broke under extreme shear load; but high strength bolts didn't—the joined steel failed first.

APPLYING THE ADVANTAGES

Since high strength bolts have 2 to 3 times more tightening strength than common bolts, smaller diameter bolts can be used. As discussed above, these make a stronger joint; also weigh and cost less.

Along with good joint design, it's important that fasteners used can meet requirements. For example: A manufacturer designed vibrating machinery for high tensile bolts, but it was assembled with low carbon bolts. Joints failed. RB&W high carbon bolts with hardened washers solved the problem.

Moral: *Specify* even your standard fasteners.

RB&W selects the proper grade of steel to give "Empire" high strength fasteners the precise balance between *tensile strength* and *ductility.*

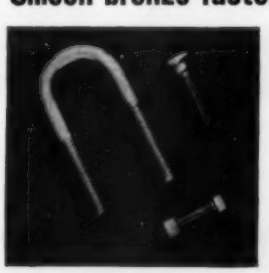
Feel free to call on RB&W for help in selection and use of standard, low cost fasteners.

Three radial dashes on bolt head denote a high strength bolt. The "E" identifies Empire bolts, an RB&W trademark. These markings assure highest quality standard fasteners with full strength, and uniformity of size and physicals.

●

Russell, Burdsall & Ward Bolt and Nut Company . . . plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Silicon bronze fasteners combine desirable features



Silicon bronze offers the highest conductivity of fasteners able to withstand high stresses. It resists corrosion, stays free from season cracking, too. It makes ideal fasteners for electrical use where tensile strength is important; or for corrosive environments.

One of the first to develop such fasteners, RB&W cold works them for tensile strength and for clean, well formed threads that don't seize. Oval bolts, hex bolts and nuts and U bolts available. Specials can be developed.

—ITEM 188—

XUM

ask the man on the production line . . .

"I want P-K® self-tapping screws . . . I make more money with 'em!"

TV production line at Motorola, Inc., Chicago, Illinois

He does! You do, too!

Pay a man on a unit basis and he wants only the fastener that speeds production and eliminates rejects. That's why P-K Self-tapping Screws are preferred by men on the assembly line. They know through actual use that Parker-Kalon Self-tapping Screws are headed, threaded, pointed and hardened to keep assembly lines trouble-free!

Men in charge of production are P-K boosters, too. They know that the cost of the fastener is a fraction of the cost of using that fastener on the line—that P-K screws are actually the most economical. That's why the men who are responsible for production specify Parker-Kalon. They know . . . if it's P-K, it's O.K.

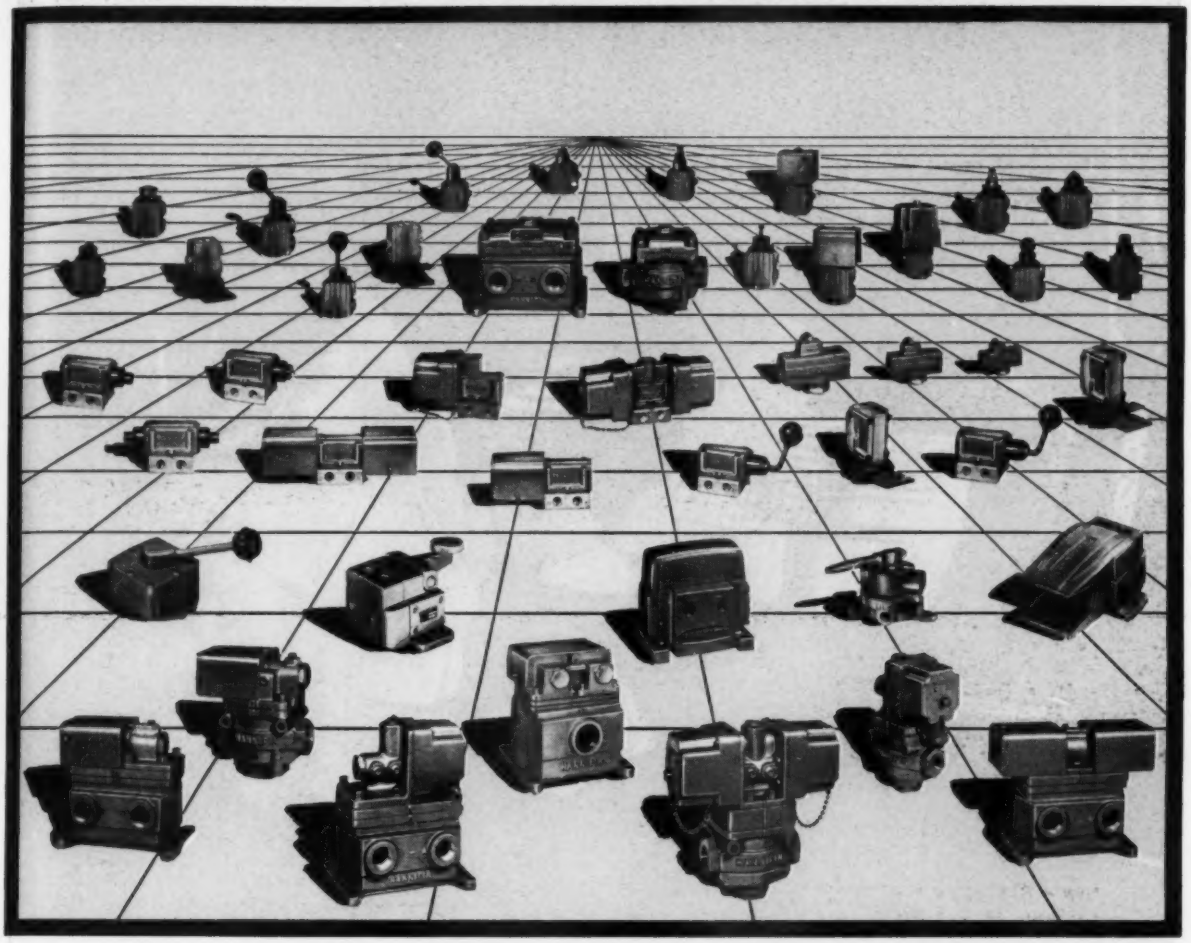
Sold Everywhere Through Leading Industrial Distributors. Warehouse In Chicago, Ill.

PARKER-KALON® *fasteners*

PARKER-KALON DIVISION • GENERAL AMERICAN TRANSPORTATION CORPORATION • CLIFTON, NEW JERSEY

—ITEM 189—
For More Information Circle Item Number on Yellow Card—page 19

FOR AIR CYLINDER CONTROL... Manual or Electric



Hannifin is your best valve source

What air control valves do you need, or prefer? Hannifin has all types—for your production lines or the machines you manufacture. They include:

P-M Pilot-Master Valves, solenoid controlled by integral pilot heads (including new-type, dust-tight, splashproof heads that completely meet J.I.C. recommendations). ⅜" to 1¼". 2-way, 3-way and 4-way.

P-M Master Valves. ¾" to 1¼". 2-way, 3-way and 4-way, air operated. For remote control from a wide choice of P-M Pilot Valves.

P-M Direct-Operated Valves. For direct control of small air cylinders. 2-way, 3-way and 4-way. ¼" and ⅜".

Disc Valves. Rotary and sliding reciprocating disc types for hand, foot or electric operation. ⅛" to ¾".

Micrometric Speed Control Valves for micrometer-like speed adjustment through control of exhaust flow.

You can simplify your air control problems by standardizing on Hannifin.

Stock Delivery On All Types

HANNIFIN

MAIL THE COUPON FOR PROMPT ACTION

- ☐ Have Field Engineer call at once
- ☐ Have Field Engineer stop by soon
- ☐ For the present, just send complete Hannifin Control Valves Catalog

Hannifin Corporation, 515 S. Wolf Rd., Des Plaines, Illinois

Name.....*Title*.....

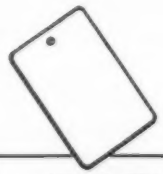
Company.....

Address.....

City.....*Zone*.....*State*.....

—ITEM 190—

When you want close quality control, *you use Bonderite under the paint.*



"GOLD STANDARD" PANELS are Bonderized

Parker's Customer Service lab prepares Bonderite-treated panels, used as the standard of comparison by manufacturers and paint companies. We have shipped about 400,000 in the last 12 months.

● The test panels in the plant laboratory tell the story: Bonderite in the finish line is the quality control engineer's friend. Performance standards are more easily maintained. And when standards are maintained in the plant, product performance in the field will please your customers.

The secret of Bonderite's uniform results begins in Parker manufacturing plants, where each lot of chemical is numbered and tested. A sample is kept permanently. Operating procedures for processing are simple, easily followed, easily checked. Long experience has smoothed out all the kinks!

Take the most positive way to control quality and assure finest paint finish, durability and appearance—use Bonderite.

******Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

—ITEM 191—

For More Information Circle Item Number on Yellow Card—page 19

70% LIGHTER

than comparable rubber-edged metal hangers ... costs less too

NYLOCLIP T.M.

NYLON CABLE HANGERS

For strong, sure support ... for sustained periods in temperature extremes from −60°F to 250°F ... these new, tough, lightweight, molded nylon cable hangers give you all the important features of metal, *plus.*

Even under severe stress, NYLOCLIP's high physical strength holds pre-formed shape indefinitely ... undamaged by oils, gasoline, alcohol, hydraulic fluids.

Self-insulating nylon is high dielectric non-conductor; eliminates hysteresis losses, grounds, shorts.

Cable insulation fully protected by rounded edges, matte finish inside surface of NYLOCLIP. Stud hole serrations running parallel to cable insure automatic alignment when screw is tightened – prevent cable chafing. Available in 17 standard sizes to accommodate cables or bundles from ⅛" to 2".

Meets MIL-STD-242 and NAVORD OSTD 600-7-3.02.29 (int.)

For proof of performance, send for samples ... to your specified sizes.

rugged strength
of Nyloclip supports this man's full weight ... 247 lbs.!

BURNDY

56-10

Norwalk, Connect. • Toronto, Canada • Other Factories: New York, Calif., Toronto • Export: Philips Export Corp.

These turboprop propeller blades

Model CT634S of the Curtiss-Wright Turbolectric series was the first U. S.-designed and built turboprop propeller to be certificated for commercial use by the Civil Aeronautics Administration. This model and others are already in quantity production for military aircraft.

Turbolectric propellers use extruded hollow steel blades produced by the controlled extrusion process developed by Curtiss-Wright. The extruded blade begins as a single-piece alloy steel billet.

With the development of this propeller and the controlled extrusion process came the need to select the right alloy steel. And here's where teamwork paid off.

Republic metallurgists, working closely with Curtiss-Wright metallurgists and engineers, selected an alloy steel with the following properties that make the extrusion process successful from both a production and cost standpoint: freedom from imperfections, uniform response to heat treatment, workability in all stages, weldability, bendability—hot or cold.

These properties in combination with the extrusion process give:

(1) IMPROVED STRENGTH-WEIGHT RATIO. The tough, integral structure of the extruded alloy steel blade provides greater strength and resistance to fatigue with minimum weight.

(2) IMPROVED QUALITY. Greater uniformity is assured by fabricating from a single homogeneous material.

(3) INCREASED PRODUCTION. The number of manufacturing operations is reduced. Production per hour is increased. Floor space is saved.

(4) REDUCED COST. Less steel for original stock, less machining, and lower cost tooling and equipment are required. Expensive welding and accompanying preheating and post-heating operations, as well as milling operations, have been reduced.

What about your product? Are you using the right steel in the right place? Republic—world's largest producer of alloy and stainless steels—offers you the services of experienced field metallurgists who will work with your staff in determining where these versatile steels can effect the greatest savings. Just send us the coupon.

Strength-to-Weight or Heat Problems—Republic Has the Answers

◀**TITANIUM SAVES WEIGHT ON DC-7** with no sacrifice in strength or safety. Republic is an old hand at this high strength-to-weigh. business. We pioneered the use of alloy steels, then stainless steels—followed by high strength steels. Now come Republic Titanium and Titanium Alloys. Years of experience gained in helping hundreds of manufacturers design and re-design their products to get more strength with less weight are available to you.

600° F TEMPERATURE HAS LITTLE EFFECT ON DE-ICER DUCTS made of Republic▶ ENDURO Stainless Steel. Because of its extremely high strength-to-weight ratio, and corrosion-resistance you can use ENDURO in thinner, lighter sections. It resists temperature extremes, holding its strength, toughness, and shock-resistance all the way from blistering heat through sub-zero cold. Republic produces ENDURO® in all commercial forms.

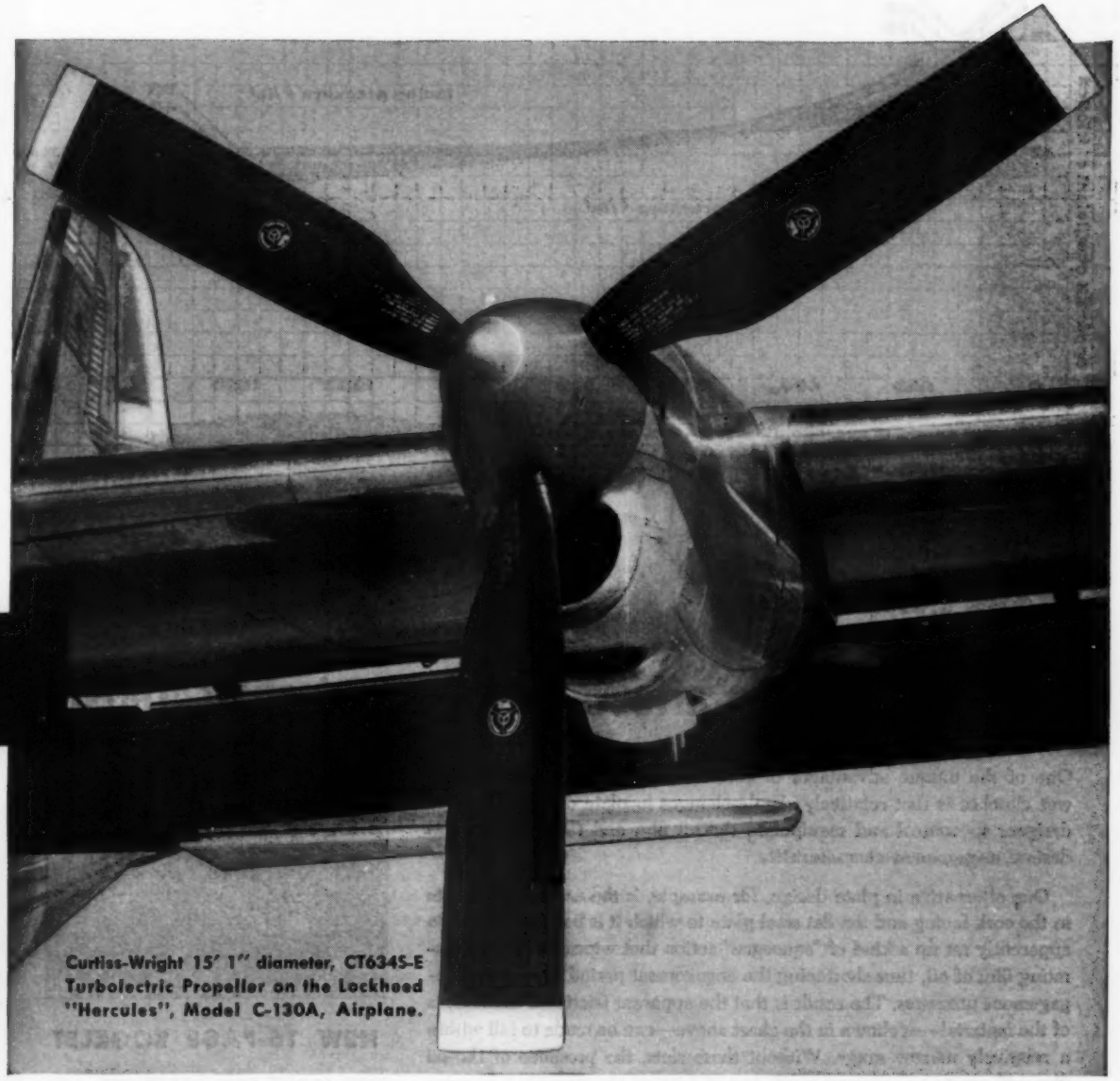
REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

XUM

begin as alloy steel billets



Curtiss-Wright 15' 1" diameter, CT634S-E Turbolectric Propeller on the Lockheed "Hercules", Model C-130A, Airplane.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
3130 East 45th Street • Cleveland 27, Ohio

Please send more information on these Republic products:
☐ Alloy Steels ☐ Titanium and Titanium Alloys
☐ ENDURO Stainless Steels

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Company_____

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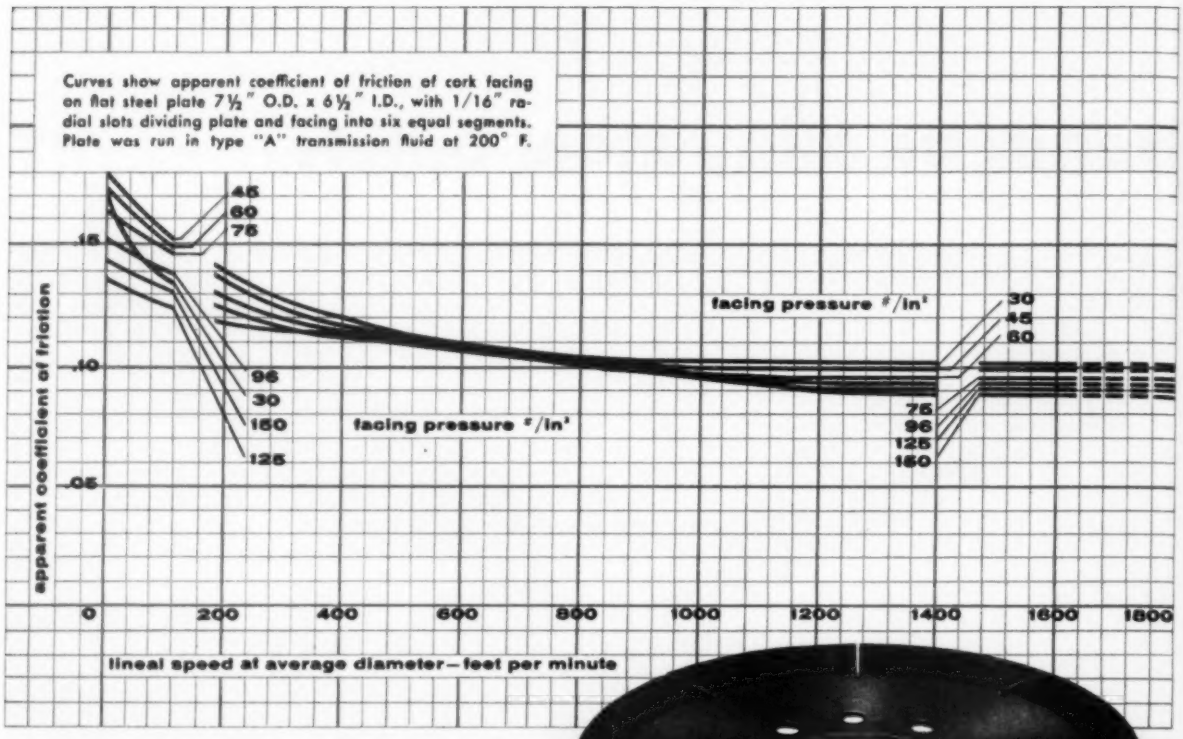
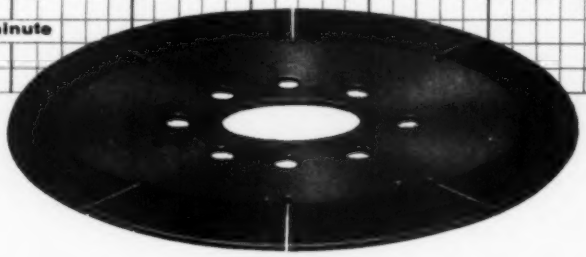
R-9661

—ITEM 193—
For More Information Circle Item Number on Yellow Card—page 19





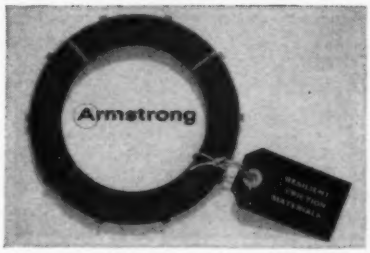
cork clutch facings:

How a slotted plate affects engagement characteristics

One of the unique advantages of cork-compound friction materials in wet clutches is that relatively simple changes in plate design allow the designer to control and manipulate the oil film and thus produce the desired engagement characteristics.

One alternative in plate design, for example, is the use of radial slots in the cork facing and the flat steel plate to which it is bonded. The slots apparently set up a kind of "squeegee" action that wipes away the separating film of oil, thus shortening the engagement period even at low engagement pressures. The result is that the apparent frictional coefficients of the material—as shown in the chart above—can be made to fall within a relatively narrow range. Without these slots, the presence of the oil film will create an apparent coefficient of friction of extremely low value at low unit pressures.

Still other engagement characteristics may be obtained by using a cork facing on a waved steel plate, on an ordinary flat steel plate, or by varying engagement pressures. Additional detailed information on this subject—along with many helpful charts and graphs—is contained in the new 16-page booklet offered at the right.



NEW 16-PAGE BOOKLET

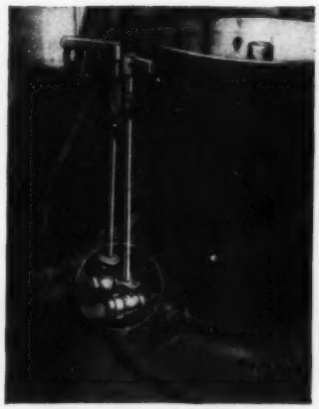
FOR MORE INFORMATION on the design versatility of cork-compound friction materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." It's free to industrial users. Write to Armstrong Cork Company, Industrial Division, 7203 Dean Street, Lancaster, Penna.

Armstrong FRICTION MATERIALS

. . . used wherever performance counts

—ITEM 194—

Valves that don't leak, earn their keep!



1½" Ball Valves on filter press. Note remote handle control. These valves have replaced the old fashioned plug cocks.

And that's one of the prime reasons this West Coast Brewery changed to Rockwood full *round* flow Ball Valves (See picture above). The top-flight performance displayed by these valves controlling the CO_2 system to the vats illustrates the drip-tight seal so necessary in conforming to the rigid standards of sanitation in this industry. This is just another example of what Rockwood Ball Valves are doing in industries of all types.

Their efficiency originates from these FOUR exclusive features —

Full Round Flow — no change in shape or volume of fluid stream — no turbulence — no minimum loss

Quick Opening and Closing — only a quarter turn needed — easily and quickly done even under high pressures

Longer Wear Resistance — Chrome plated bronze ball withstands abrasion, pitting and scratching

Leakproof Seal — pressure of fluid automatically positions ball against seat to form tight seal

If you are not now using Rockwood Ball Valves, send coupon today for complete information. Valves come in all pipe sizes. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
730 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

Name.....

Title.....

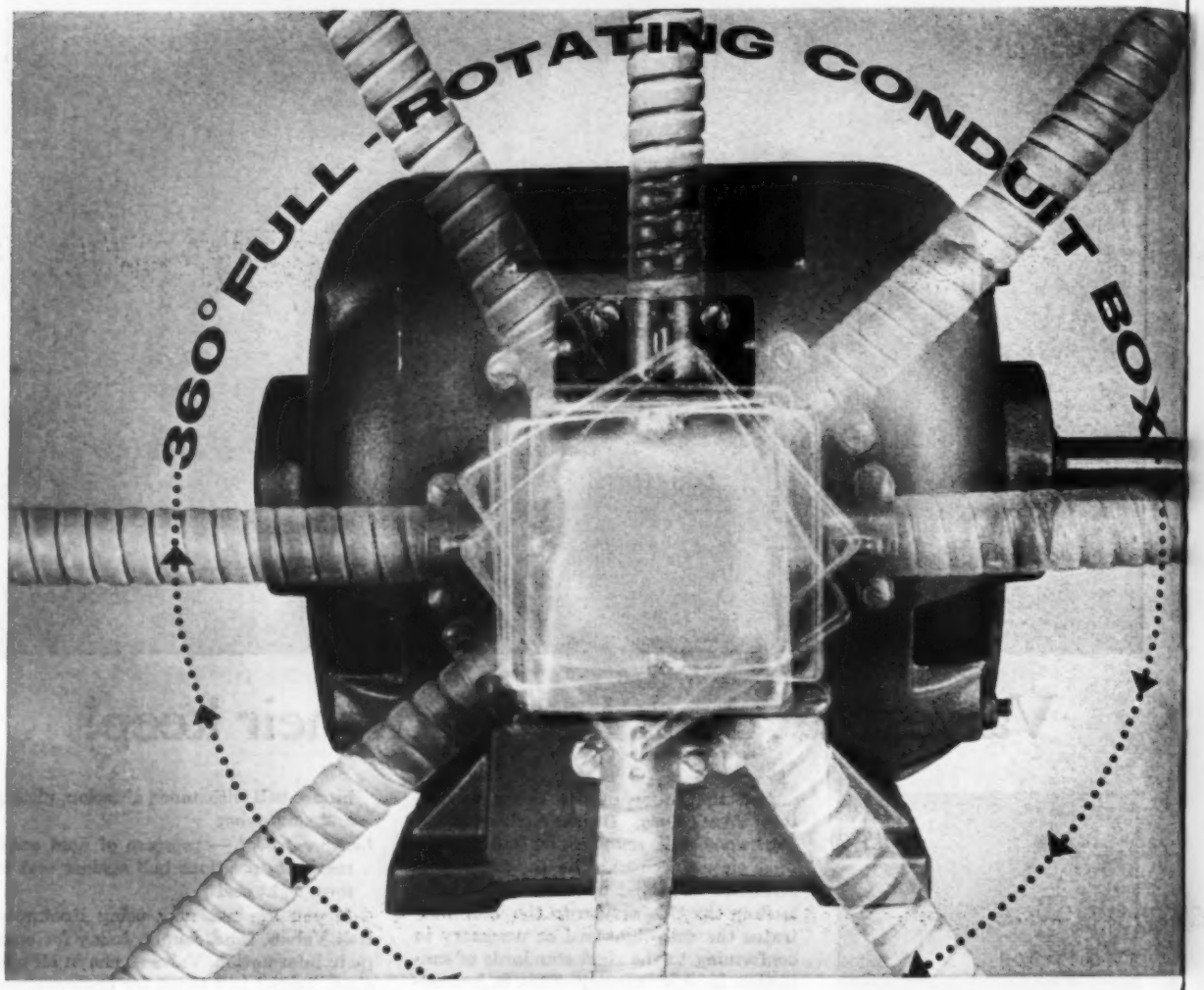
Company.....

City.....

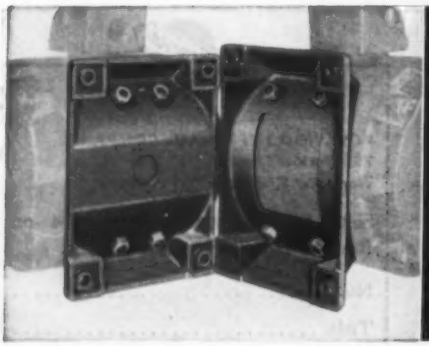
Zone.....State.....

—ITEM 195—

EXCLUSIVE in

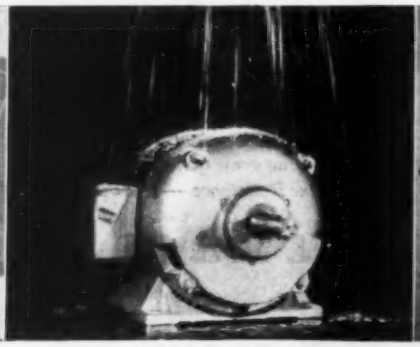


You get these quality A. O. Smith motor features...



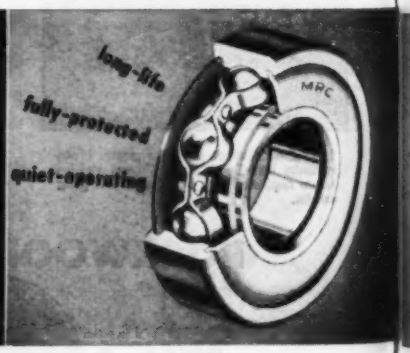
OPTIONAL FRAME MOUNTINGS

There's no need to change product design to use new NEMA frame sizes. A. O. Smith gives you frame mountings drilled to old and new specifications.



DRIP-PROOF CONSTRUCTION

Motor can be mounted in any position . . . drip-proof thru 360° cycle . . . simply rotate end brackets. No foreign matter can enter vent holes.



PRE-LUBRICATED BEARINGS

Shielded bearings assure protection against over greasing . . . provide even load distribution under all working conditions . . . quiet operating.

A. O. Smith integral hp motors

Saves space... speeds motor installation... convenient design for easy connection of leads

JUST one example of the many exclusive features you get with A. O. Smith integral hp motors is the full-rotating conduit box. This advance design permits you to connect terminal leads from any angle without re-positioning the motor once it's installed.

The conduit box may be rotated through a full 360° by simply removing the cover and loosening three screws. And a special gasket is used to seal-out the moisture... no chance for corrosion, a major cause of power failure.

It's good business to specify A. O. Smith integrals, because you get motors that are application-engineered to match the performance and quality of your product. You can say goodbye to the problem of adapting your product to the design limitations of conventional motors.

And remember — for your design or speed requirements, there's an A. O. Smith integral hp motor available to power your products. Integrals are built in single-phase (1-7½ hp) and polyphase (1-150 hp)... in various speeds and frequencies... choice of frame mountings for either old or new NEMA dimensions... C and D flanges as required.

Produced by one of America's great industrial concerns, these motors are backed by a national network of 270 strategically located factory service stations. There's one near you — ready to provide 24-hour service on all parts and service orders.

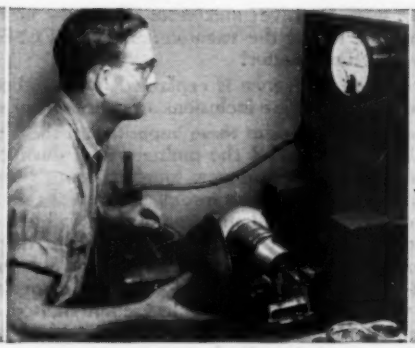
For more information on A. O. Smith integral hp motors, write for new Bulletin No. EM156.

Through research ... *a better way*

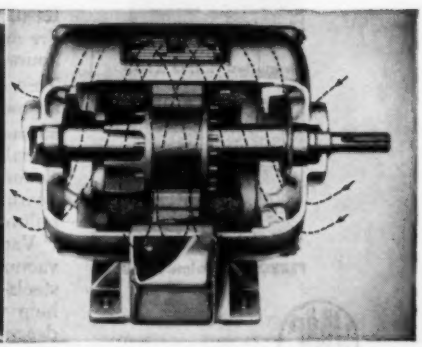
A.O.Smith
CORPORATION
ELECTRIC MOTOR DIVISION
TIPP CITY, OHIO
International Division: Milwaukee 1, Wisconsin

application-engineered to match your product requirements

SEALED STARTING SWITCH AND ACTUATOR
Exclusive development... totally-enclosed in end frame. No need to remove motor from line for switch service.



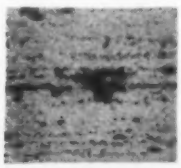
DYNAMICALLY-BALANCED ROTOR
Assures continuous, vibrationless, trouble-free performance and maintains long bearing life. Indestructible laminations are high-quality silicon steel.



CONTROLLED THRU-VENTILATION
Cooling system designed for high-volume, low velocity air for maximum heat transfer. Temperature held to absolute minimum, assuring longer insulation life.

Vacuum-melted steel boosts bearing life 620%

Photomicrographs showing typical improvement in cleanliness.



Air melted Halmo X100

FERROVAC Halmo X100

Not long ago, an anti-friction bearing manufacturer compared bearings fabricated from air-melted Halmo (1 vanadium, 0.65 carbon, 5 chrome, 5 molybdenum, balance iron) steel with bearings of the same steel made by vacuum melting. Test conditions were identical: heavy overload–high speed–400F–oil jet lubrication.

Results were decisive: *maximum* life of the air-melted bearings was 150 hours . . . the *average* life of the vacuum-melted or FERROVAC® Halmo bearings was 1080 hours–6.2 times better!

This marked difference is explained by the photomicrographs at the left. Note the air-melted alloy. Here inclusions are warnings of early bearing failure.

But note the absence of these impurities in the FERROVAC Halmo steel. They were literally sucked out of the molten metal during the vacuum process. The result is cleaner steel that's stronger, tougher, more resistant to wear and fatigue. And, in bearing applications, this means substantial reduction of the scatter band (spread of failures) . . . *virtual elimination* of early failures.

Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, now has them available in tool, high-speed, stainless and alloy steels–in most sizes and grades–as well as special ferrous and nonferrous alloys. For help with metal problems that vacuum-melted alloys might solve, please write us, describing them in as much detail as possible. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

VACUUM METALS CORPORATION

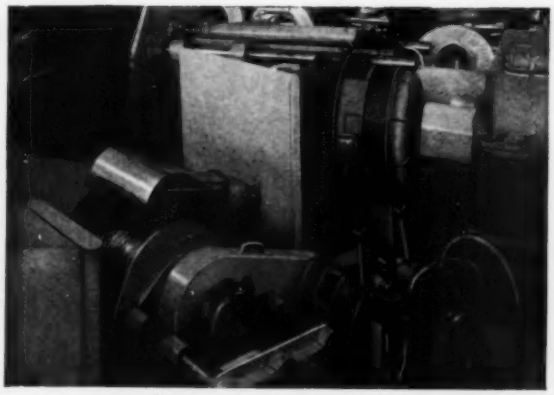
Jointly owned by Crucible Steel Company of America and National Research Corporation

—ITEM 197—

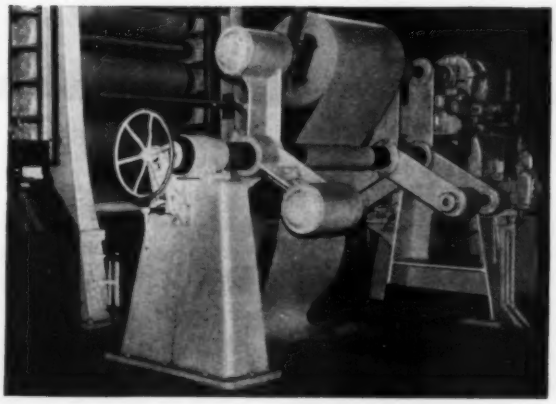
Tension Control Problems?

Dynamatic's Long Experience in Solving Industrial Windup and Unwind Problems will be Valuable to You

DYNAMATIC®



Metal slitter powered by Dynamatic Drives. Adjustable speed liquid cooled coupling used as main drive; Ajusto-Spede® Drives, with constant tension control, wind up the metal strips.



Completely Dynamatic driven paper super-calender. Adjustable speed liquid cooled couplings with Eddy-Current brakes drive the calender rolls and center rewinder. Dynamatic liquid cooled brake provides center unwind hold-back. Co-ordinated controls provide for wide-range adjustment of speed and tension.

Dynamatic Eddy-Current Drives with tension controls are used extensively in the fields of paper, rubber, textiles, ferrous and non-ferrous metals, plastics, and printing.

Combined with associated controls, Dynamatic Eddy-Current Drives provide automatic constant tension as the roll diameter changes on center rewinds and unwinds. Constant tension is maintained over a wide range of material delivery speeds without the use of dancer or follower rolls. Controls may be adjusted for tapered tension to increase or decrease tension automatically as the roll changes diameter.

Multi-range tension or tension adjustment over a wide range is easily accomplished at the operator's station to accommodate materials of various thicknesses or widths. Control modifications are available to provide for inertia compensation and other individual requirements. Dynamatic engineers are available for consultation on your problems.

Bulletins giving detailed information on Dynamatic Tension Control will be sent free at your request.

EATON

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE · KENOSHA, WISCONSIN

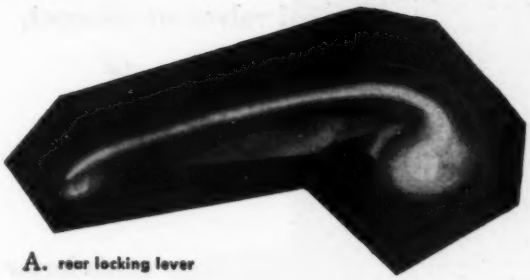
—ITEM 198—

MUELLER BRASS CO. FORGINGS

give THUNDERBIRD tops a snug fit the year around

The Motor States Products Division of Detroit Harvester Co.—a major supplier of top assemblies for convertibles—has found Mueller Brass Co. forgings an ideal answer for securely fastening down the tops on the Ford Thunderbird. In a summer shower or in the snow of winter the top is always snug and draft-free. There are a pair of each of the three Mueller Brass Co. forgings shown here used in locking the Thunderbird top securely around the sides and rear deck. The locking lever (A) is incorporated in the top and operates a locking pin that fastens into the rear hold down clamp (B). A pair of side hold down clamps (C) are located just behind each door opening and clamp fasteners on the top hook into these forgings to rigidly hold the top in position. These forgings hold the necessary close tolerances and provide an excellent surface for buffing and chrome plating. In addition, the price is favorable and deliveries are good. For these reasons, as well as their inherent strength and durability, a switch to Mueller Brass Co. forgings can prove advantageous. Write today for our engineering manual (No. H-58565) . . . or better yet, call in one of our engineers to investigate possible forging applications in your products.

XUM



A. rear locking lever

B. rear hold down clamp

C. side hold down clamp

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY, Director of Research

The other day one of our sales engineers stopped in to discuss gear applications and the subject got around to the amount of zinc permissable in gear and bearing alloys. Engineering books state that zinc is not desirable in bearing alloys. While this statement is true as regarding the commonly used copper-tin and copper-tin-lead alloys, it does not necessarily apply to other types of alloys. The 600 series bearing alloys, in which I am keenly interested, depend upon a high zinc content along with several other metal constituents to provide them with their fine bearing properties.

My explanation to our sales engineer was somewhat as follows: The question as to whether or not zinc is detrimental in a bearing alloy depends upon the remaining constituents in the alloy. A comparatively small amount of zinc is detrimental in a phosphor bronze alloy containing 80% copper, 10% tin and 10% lead. A zinc content of 4% is permissible in a bearing alloy containing 88% copper, 4% tin and 4% lead when used in an application not subject to heavy loads. In these alloys the tin combines with some of the copper to form a hard copper-tin constituent which is distributed through the soft copper matrix, or mat of copper. The higher the percentage of tin present, the greater the quantity of hard copper-tin constituent formed. Zinc also combines with copper increasing the hardness of the matrix. Therefore, when zinc is present along with a high tin content, the matrix becomes too hard and is "out of balance" resulting in poorer bearing qualities.

In the 600 series, copper, silicon, manganese, etc., are present with zinc. There is sufficient manganese present to combine with the silicon to form a purple manganese silicide which is embedded in the copper-zinc matrix. *Since the manganese-silicide constituent has a much higher micro hardness than the copper-tin constituent in phosphor bronze, the matrix of the 600 series alloys can have a higher hardness without impairing the bearing properties. In this instance, zinc is not detrimental but desirable because it produces an alloy with a high Brinell hardness which resists pounding and distortion.*

Like many engineers, we, too, were skeptical of the bearing properties of the first 600 alloy developed. A manufacturer of worm driven truck transmissions was having difficulty with the failure of chill cast high tin bronze gears in busses used in the hilly section of Los Angeles and Pittsburgh, and solved his problem by using gears made from 600 metal.

Since that time, we have had over a hundred successful applications on difficult bearing problems where cast bearing bronzes have failed. An interesting observation is that once a customer uses 600 alloys, he not only finds other applications, but continues to use it over a long period of years. Our original customers are still on our books.

In conclusion, we agree that zinc is detrimental to the bearing properties of the phosphor bronze type of alloys, but is of benefit to the 600 series alloys, *as it makes a harder matrix*, permitting the alloy to resist pounding action better than the softer phosphor bronze alloys.

I've just about run out of space for this time but we'll have another subject for discussion later. If you have any problems or questions about non-ferrous alloys, just write me here at Mueller Brass Co. and we'll see what we can do.

MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

170

BIGGER THAN YOU THINK

Skinner solenoid valves are compact, tiny and lightweight.

But don't be misled — they'll easily outperform other valves that are much larger and heavier. Built to withstand high voltages and temperature extremes, Skinner valves provide leakproof, trouble-free operation through millions of cycles.

And being small, they are easily adaptable to your most compact equipment design. Call in a Skinner engineer on all your valve problems *first*. He can draw from over 100,000 variations . . . all of them *big in capacity, power and performance.*

Write for the new Skinner Solenoid Valve Catalog. On your letterhead, please.

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVE DIVISION · SKINNER CHUCK COMPANY

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES ®

115 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

—ITEM 200—
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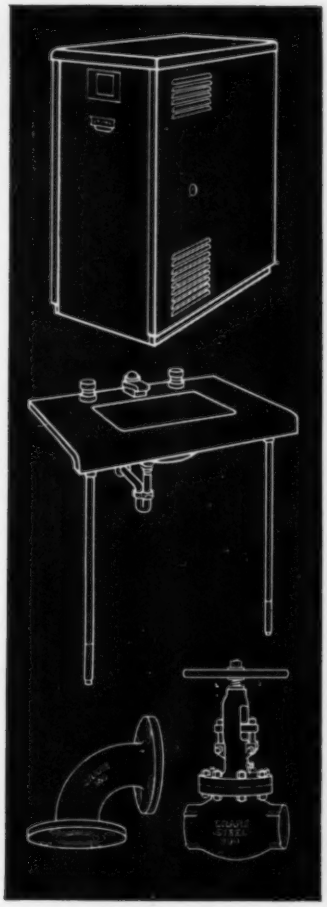


"Business Publications keep us on top of latest developments"

says **FRANK F. ELLIOTT** President, Crane Co.

"We sell more than 40,000 products in dozens of markets," continues Mr. Elliott, "and to keep our sales curve healthy we need up-to-date facts upon which to base decisions. That's the reason we read business publications *regularly* – advertisements as well as news."

Management men in all industries regard business publications as their best source of *reliable, timely* news about every phase of business.

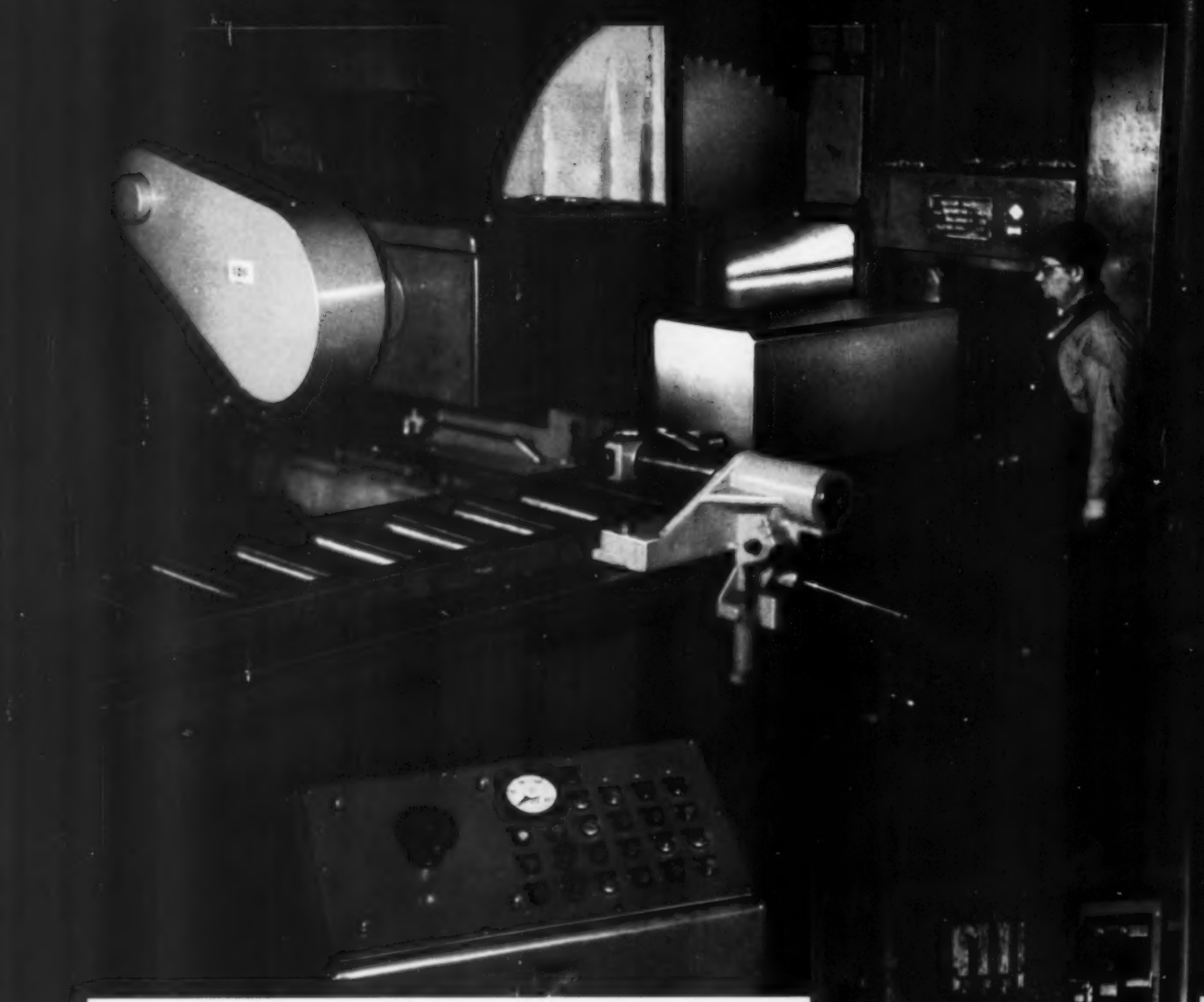
It's no wonder advertisers find business publications provide a direct sales route for any product or service of benefit to business or professional men.

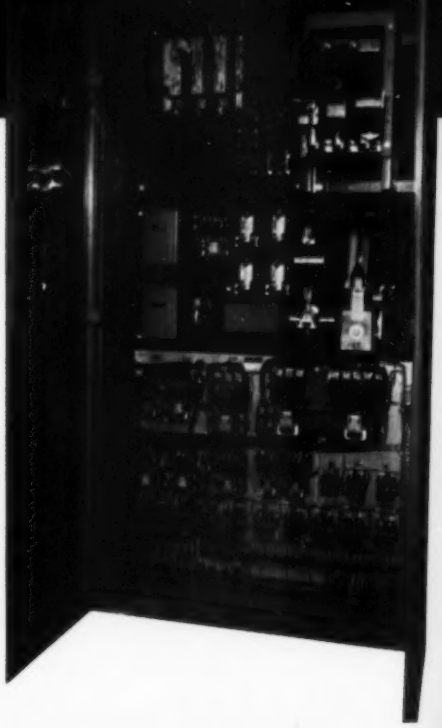
NATIONAL BUSINESS PUBLICATIONS, INC. *1413 K Street, N. W., Washington 5, D. C. • STerling 3-7535*

The national association of publishers of 173 technical, professional, scientific, industrial, merchandising and marketing magazines, having a combined circulation of 4,098,937 . . . audited by either the Audit Bureau of Circulations or Business Publications Audit of Circulation, Inc. . . . serving and promoting the Business Press of America . . . bringing thousands of pages of specialized know-how and advertising to the men who make decisions in the businesses, industries, sciences and professions . . . pin-pointing the market of your choice.

Write for a list of the NPB publications and the "Here's How" booklet, "How Well Will We Have to Sell Tomorrow?", written by Ralston B. Reid, Advertising & Sales Promotion Manager of the Apparatus Sales Division, General Electric Company.

G-E general purpose control





GIANT SAW EQUIPPED WITH G-E CONTROL SLICES 3½-FOOT ALUMINUM INGOTS

This specially designed high-speed circular saw, one of the largest of its kind ever manufactured, is installed in the U.S. Air Force plant No. 47, operated for the Air Force by Aluminum Company of America and located in Cleveland, Ohio. The saw cuts aluminum ingots up to 43 inches thick in preparation for the forging of wing spars for jet aircraft.

Manufactured by Motch and Merryweather, the huge saw is equipped with General Electric control. The main control panel shown here is custom-made for this particular application, yet contains standard high-quality G-E relays, magnetic contactors and starters, and other devices.

G-E Oil-tight Push Buttons Control 23 Operations on Giant Saw

Motch and Merryweather engineers specified G-E oil-tight push buttons for this giant saw because of their exceptionally long service life, and their ability to keep out the fine aluminum chips which might cause ordinary push buttons to fail. Also, the proved dependability of these pushbutton units assured customer satisfaction.

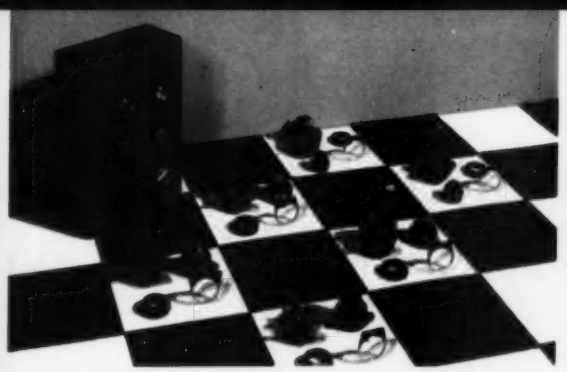
Twenty-three push buttons and selector switches were mounted in the separate control station, shown at right. The Motch and Merryweather engineers found the brilliantly colored pushbutton rings helped achieve the modern, streamlined appearance of this colorful machine.

Why don't you check into the possibility of using G-E oil-tight push buttons for your machines? Write for bulletin GEA-5779, Section 731-1, or contact your nearest G-E Apparatus Sales Office or Distributor.

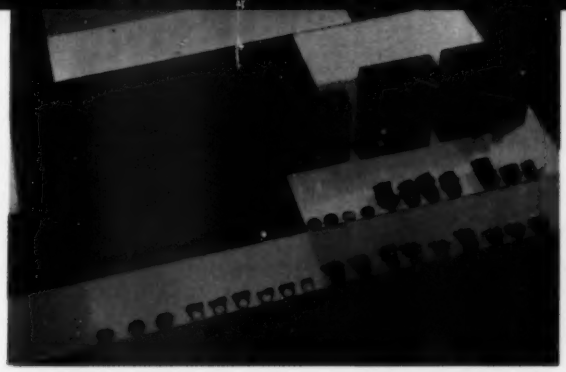
GENERAL ELECTRIC

BLOOMINGTON, ILLINOIS

COMPLETE SELECTION—UNEQUALED FLEXIBILITY—WITH G-E OIL-TIGHT PUSH BUTTONS

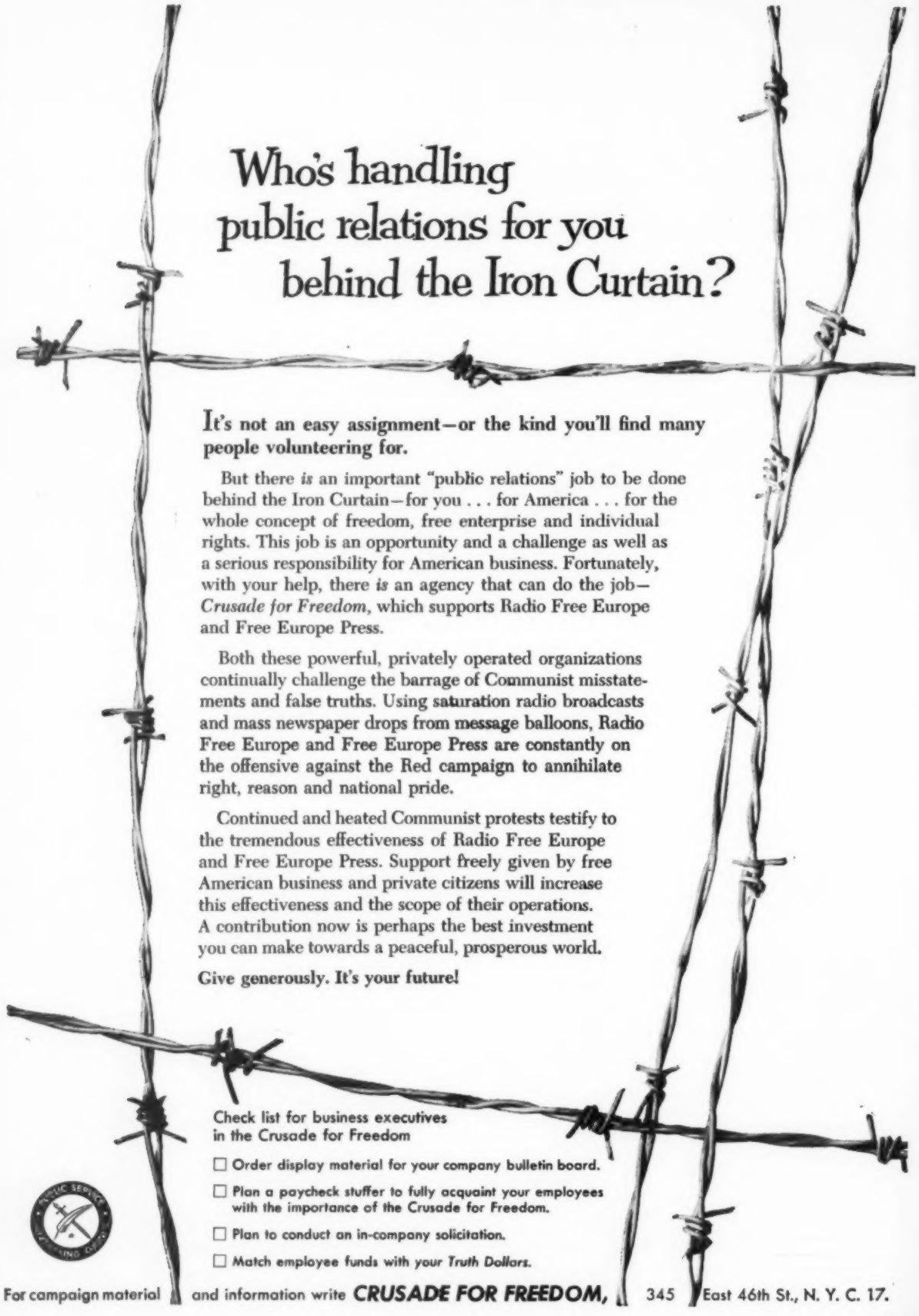


UNEQUALED FLEXIBILITY is provided. The same contact block can be used either singly or in combination with all of the separable operators. The glass lenses for all the indicating lights are also interchangeable.



COMPLETE SELECTION of push buttons, selector switches, and indicating lights is available. Using various arrangements of color rings, operators, and contact blocks, hundreds of combinations are available.

XUM



Who's handling public relations for you behind the Iron Curtain?

It's not an easy assignment—or the kind you'll find many people volunteering for.

But there *is* an important "public relations" job to be done behind the Iron Curtain—for you . . . for America . . . for the whole concept of freedom, free enterprise and individual rights. This job is an opportunity and a challenge as well as a serious responsibility for American business. Fortunately, with your help, there *is* an agency that can do the job—*Crusade for Freedom*, which supports Radio Free Europe and Free Europe Press.

Both these powerful, privately operated organizations continually challenge the barrage of Communist misstatements and false truths. Using saturation radio broadcasts and mass newspaper drops from message balloons, Radio Free Europe and Free Europe Press are constantly on the offensive against the Red campaign to annihilate right, reason and national pride.

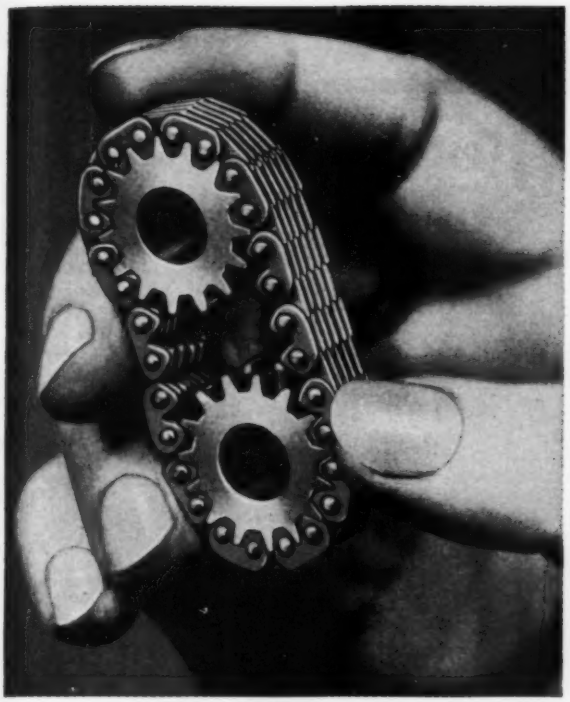
Continued and heated Communist protests testify to the tremendous effectiveness of Radio Free Europe and Free Europe Press. Support freely given by free American business and private citizens will increase this effectiveness and the scope of their operations. A contribution now is perhaps the best investment you can make towards a peaceful, prosperous world.

Give generously. It's your future!

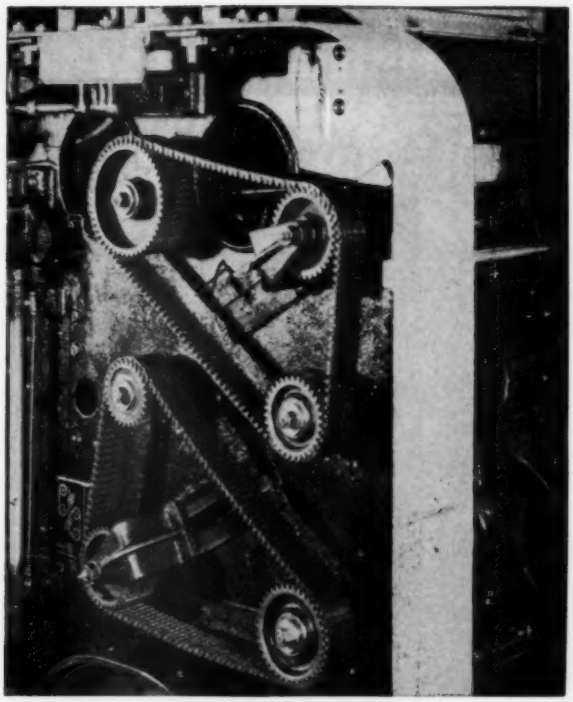
Check list for business executives in the Crusade for Freedom

- ☐ Order display material for your company bulletin board.
- ☐ Plan a paycheck stuffer to fully acquaint your employees with the importance of the Crusade for Freedom.
- ☐ Plan to conduct an in-company solicitation.
- ☐ Match employee funds with *your Truth Dollars.*

For campaign material and information write **CRUSADE FOR FREEDOM,** 345 East 46th St., N. Y. C. 17.



Drives for Small or Large H.P. For example, this tiny Link-Belt 3/16-in. pitch Silent Chain is widely used by top designers for positive, flexible fractional horsepower transmission at speeds ranging up to 9000 rpm.



Drives for High or Low Speed. High horsepowers and high speeds are delivered with the same trouble-free efficiency (over 98%) as on less severe service. Positive tooth-to-tooth action provides constant ratio for full productive capacity.

Big reasons why LINK-BELT Silent Chain is specified for so many drives:

- Lower cost—often lower in first cost, always lower in ultimate cost.
- Longer life—trouble-free performance for 20 to 30 years is common.
- No dismantling machine or removing sheaves for repairs.
- Better than 98% efficiency.
- Maintained ratio assures full productive capacity.
- Slipless action assures a better product.
- Easy to install.
- Safe to employees—operates in oil-retaining casing.

SILENT CHAIN is just part of the complete Link-Belt line. You can choose from all types and sizes of cast, combination, forged and fabricated steel, roller or silent chains—with matching sprockets. No matter what your drive or conveying needs, you're sure of getting the *right* chain for the job.

Get the complete Link-Belt Silent Chain story from Book 2425. Or send for Catalog No. 950 . . . a handy source for all the facts on industry's broadest chain line.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,721

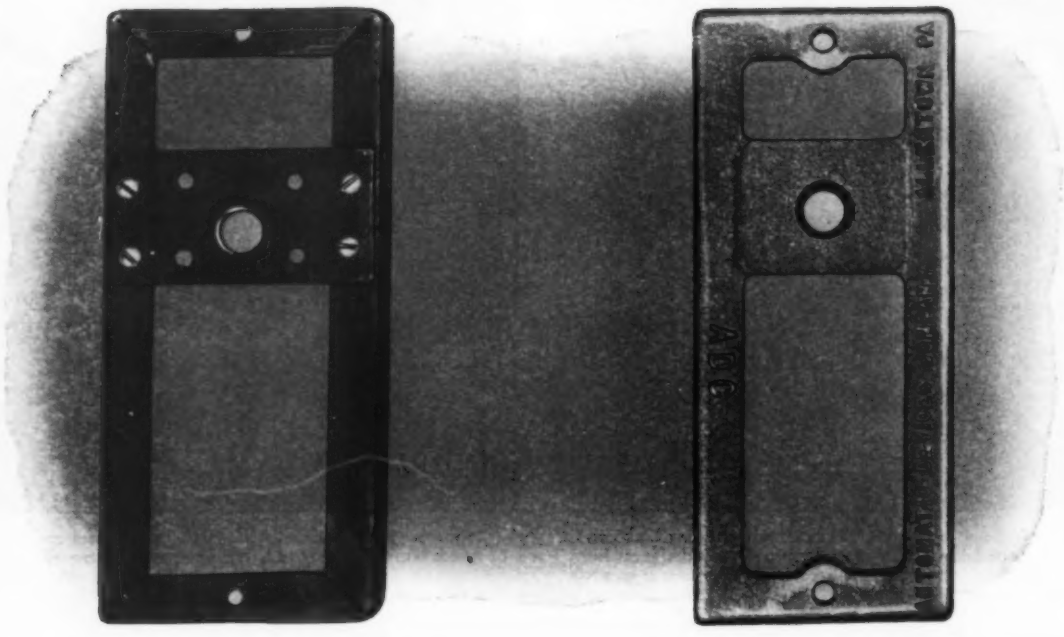
—ITEM 204—

For More Information Circle Item Number on Yellow Card—page 19

XUM

Cost Welded $2.40

Cost in Gray Iron $1.10



Which Would You Buy?

This symbol assures you the most for your casting dollar

Here's why it pays to call in one of the more than 500 leading foundries displaying the Society symbol:

- The most recent technical and business information is available to each member through the Society to help you design better products at lower cost.
- The use of sound cost accounting procedures is recommended and encouraged among Society member foundries, assuring full value for your casting dollar.
- Improved castings result from the advanced techniques and the high sense of responsibility of Society members.

MAKE IT BETTER WITH GRAY IRON

Besides saving over 50% on the cost of this motor mount, the Gray Iron casting provides greater rigidity, and better appearance. The casting process also provides a simple means for manufacturer identification. Obviously, Gray Iron is the better buy.

A quick look at *your* products will uncover applications where time-tested Gray Iron can improve your products and reduce your costs.

Review the features of Gray Iron—durability . . . vibration absorption . . . noise elimination . . . rigidity . . . heat and corrosion resistance . . . low notch sensitivity . . . wide strength range. These advantages, plus dollar *savings*, make it worth your while to think of Gray Iron *first*.

For specific technical or business information about Gray Iron, write direct to Gray Iron Founders' Society, Inc., National City—East 6th Building, Cleveland 14, Ohio.

GRAY IRON FOUNDERS' SOCIETY

Fluid Systems That Need Frequent Disconnection

NEED AEROQUIP SELF-SEALING COUPLINGS

For Freon 12 & 22

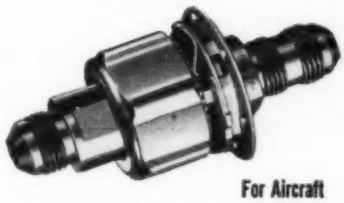
Aeroquip 511017 Self-Sealing Coupling for refrigeration and air-conditioning applications makes low cost field installation possible by permitting factory charging of the units and lines of various lengths. Mates with sweat-type adapters.

For LP Gas

Aeroquip 5102 Self-Sealing Coupling speeds recharge of LP-Gas fuel tanks on trucks, tractors. Coupling has Acme and P.O.L. threads to fit any recharge line. Absolutely no leakage of fuel upon connecting or disconnecting.

For Farm Implements

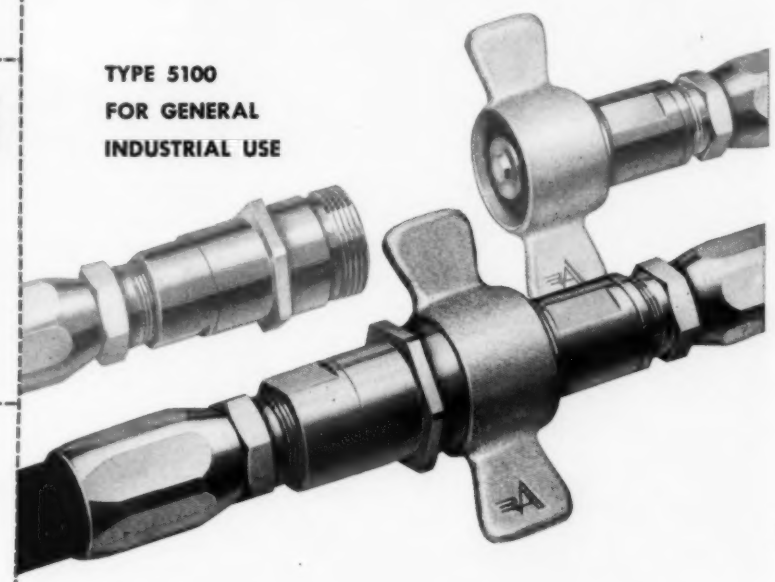
Aeroquip 5203 Self-Sealing Coupling provides quick, easy interchange of hydraulic trailing and tractor-mounted equipment. Mates with the Aeroquip Breakaway.



For Aircraft

Aeroquip 155 & 145 Self-Sealing Couplings speed inspection, servicing or replacement of engines and other aircraft fluid system components. Ideal for engine test stands.

TYPE 5100
FOR GENERAL
INDUSTRIAL USE



Aeroquip Self-Sealing Couplings permit quick connection and disconnection of fluid lines under pressure, without loss of fluid or inclusion of air into the system.

Type 5100 coupling has a wide range of industrial uses on air, water, hydraulic, fuel and lube oil lines. It is ideal for stationary and mobile equipment where fluid-carrying lines must be disconnected and reconnected frequently for servicing, moving, or interchanging of parts and accessories.

CATALOG No. 200 contains complete information on Aeroquip Self-Sealing Couplings and flexible hose lines with reusable fittings, plus valuable fluid line data. Write for your copy.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

—ITEM 206—

XUM

satisfied customers keep coming back!

Here's a lady pleased pink with a new dishwasher . . . so enthusiastic a booster for someone's product she can hardly wait to tell about it, and a sure-fire prospect for future appliance needs. Chances are that a Packard Electric motor has a lot to do with her satisfaction, for Packard motors deliver quiet, dependable, long-lasting performance that's bound to please.

For more than 39 years, Packard Electric craftsmen have been building fractional horsepower motors that lead to one satisfied customer telling another. Packard builds a lot of satisfaction into every motor . . . and there's nothing better than a satisfied customer to boost both reputation and sales.

GM GENERAL MOTORS Packard

REG. U.S. PAT. OFF.

Packard Electric Division
General Motors, Warren, Ohio

—ITEM 207—

(Advertisement)

DESIGNING WITH ALUMINUM

NO. 17

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

REDESIGNING FROM STEEL TO ALUMINUM SHEET

The development of versatile, high-strength aluminum alloys has enabled many manufacturers to convert their metal products to aluminum from other materials.

Redesign is not complicated, and tremendous improvements often may be gained by application of aluminum. Advantages include easy forming, greater facility of handling, lower shipping costs, longer service life, elimination of need for paint and other protective coating, reduced maintenance and more attractive appearance, along with other desirable features.

Among the especially striking applications in which aluminum parts may be introduced are those involving the redesign of sheet steel products into aluminum. ("Sheet" materials in both metals are those up to .249" in thickness.)

This process requires no more than ordinary design acquaintance with the physical and mechanical properties of aluminum alloys. Aluminum may be formed and joined by any of the familiar methods for metal fabrication, and by a number of other dependable means that most other metals do not accept readily. For example, deep cup-shaped parts may be made in one piece accurately and to finished dimensions without joints from aluminum by impact extrusion or spinning. Such parts are made from steel by expensive forming or hot forging processes followed by final machining and forming of body and base components.

Another simple forming method that is accepted by few metals other than aluminum is "stretch forming," in which the aluminum sheet is stretched over a male die, and provides three-dimensional contours of considerable dimensional accuracy.

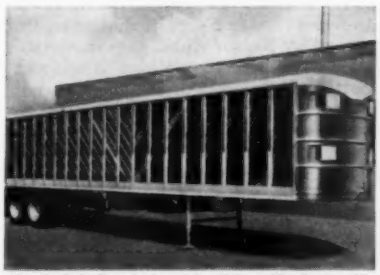
Built-up Structures

Where structures are built-up from several sheet metal pieces, aluminum may be joined by stitching, stapling, adhesive bonding and other quick-assembly methods. These have a very distinct advantage over the more expensive and time-consuming assembly procedures suitable for steel sheeting. For this reason, designing with aluminum sheet materials very often offers important savings in manufacturing costs plus the functional advantages of the finished aluminum parts.

Sheet products generally fall into two classes; load-bearing parts and comparatively unstressed parts. Sheet pieces and assemblies of the latter sort include covers, hoods, ducts, light housings and similar parts that are expected to carry only their own weight plus the nominal pressure of ordinary handling and wear. Such parts often are designed successfully by the experienced designer's "rule of thumb" with no detailed stress analysis made or required.

Designing Unstressed Aluminum Pieces

When designing these comparatively unstressed aluminum pieces and assemblies as replacement for steel, designers need consider only the comparative



Livestock trailer designed by Kaiser Aluminum with modifications by Wilson Trailer Company shows extensive use of stressed aluminum sheet components.

stiffnesses (elastic moduli) of the two metals. Calculations have shown that an aluminum sheet 42% thicker than one of steel will have approximately an equal stiffness and dent resistance. Thus, if the design of a sheet steel hood, cover, enclosure or similar unstressed unit has been calculated as adequate, it may be replaced in aluminum simply by an increase in sheet thickness of less than one-half. Even with the thickness increase, weight will be reduced by more than one-half.

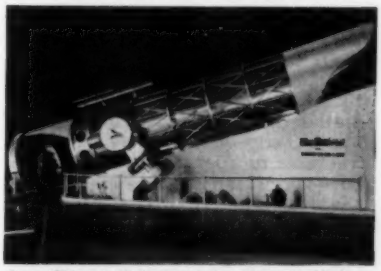
It must be remembered that some sheet metal parts of this nature are constructed according to a designer's personal inclination, calling for some arbitrary minimum of metal gauge, regardless of whether the product's end use will call for such rigidity. Where this has been done, the replacement aluminum sheet often may be no thicker than the steel, or in any case may be of a gauge increase less than the prescribed 42%. This is especially true of smaller parts where the "l/r" ratio of gauge to span is favorable. In such cases, manufacturing costs may be reduced further by actual stress investigation of the parts. The same principles, of course, may be applied in designing stressed aluminum sheet members.

Designing Loaded Aluminum Pieces

Loaded sheet-metal members are found in many design applications. They are used as chutes and guides, as table-type surfaces, as webbing in composite beams and frame structures, in the form of tank shells, and in a multitude of other components where the characteristics of sheet are desirable. The strength and durability of aluminum sheet in such applications are remarkable. For example, a 13′ x 8′ truck platform frame, designed in aluminum sheet materials as a counterpart of a steel assembly, has been found to weigh only 144 pounds—one-third the weight of the steel frame. This formed aluminum sheet structure accepts compression from a 22,500 lb. axle loading, while offering a safety factor of 4½ over the ultimate strength of its metal. Similarly, an all-aluminum livestock transport trailer (see illustration), designed by Kaiser Aluminum with modifications by Wilson Trailer Co. to meet special operating conditions, shows numerous applications of stressed aluminum sheet and weighs some 2800 lbs. less than comparable equipment of ordinary materials. The structural qualities of aluminum sheet materials have been proved in many other industrial applications as well.

Design of Stressed Aluminum Pieces

Redesign in aluminum of stressed steel sheet members will pose no difficulty to designers who are familiar with the



Decorative use of stressed and unstressed aluminum sheet at Kaiser Aluminum exhibit at Disneyland.

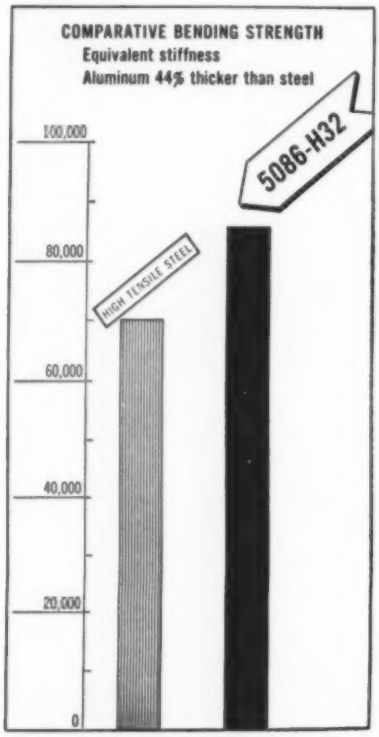
basic rules for computing structural strength. Aluminum alloys have a mod-

CONTINUED ON NEXT PAGE

XUM

DESIGNING WITH ALUMINUM Cont.

ulus of elasticity established as 10,300,000 psi, as compared with a modulus of about 29,000,000 for structural steel. The relative stiffness characteristics of the two metals, then, are in the proportion of 29,000,000/10,300,000, or (approximately) 2.8 to 1. It will be recalled that the rigidity of a section increases as the cube of its depth. For this the stressed aluminum sheet dimension need be increased by only the prescribed 42%, so as to equal its steel counterpart in stiffness.



HIGHEST BENDING STRENGTH

Most materials, including aluminum, tend to lose strength as their temperature rises. Aluminum offers a valuable measure of safety against this effect because of its high conductivity and specific heat. The specific heat of aluminum alloys permits them to absorb approximately twice as much heat energy as steel before reaching a given temperature. In addition, the capacity of aluminum to carry heat away from the point of application is about four times that of steel alloys. This resistance to temperature rise and the rapid distribution of heat energy often enables aluminum structures to operate successfully in above-normal temperature conditions.

This resistance to above-normal temperatures extends not only to strength characteristics, but to corrosion-vulnerability as well. The increased tendency of steel to rust in elevated temperatures is familiar to anyone who has observed the appearance of ferrous parts in and around above-normal temperature processes. Accelerated oxidation may be combatted in steel only by means of carefully applied and maintained protective coatings. Aluminum members, protected by their own self-produced film of oxide, are much less subject to attack and require no such intensive maintenance measures.

In many applications, the use of a machine or structure is subject to regulations imposed by law or by advisory bodies. For purposes of this nature the light weight, heat-resistant, non-sparking qualities of aluminum alloys have been accepted enthusiastically.

For example, where aluminum sheet is to be applied as a replacement for steel in cargo tank trucks for carrying petroleum products and corrosive liquids, the Interstate Commerce Commission has provided a formula to be used in determining the equivalent gauge for materials other than steel.

This formula is:

$$A = B x^3 \sqrt{\frac{3 \times 10^7}{C}}$$

A means — Thickness for materials other than steel

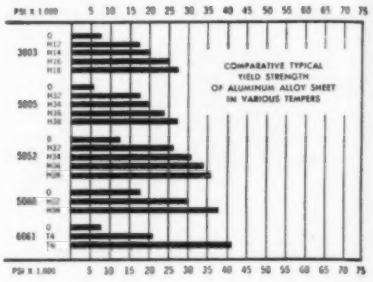
B means — Steel thickness

C means — modulus of elasticity of the alternate material

A 6000-gallon aluminum semi-trailer transport tank, 5′ 8″ in diameter, designed by Kaiser Aluminum in accordance with these regulations, is self-supporting for a span of 26 feet between kingpin and center of rear tandem. Its construction is of aluminum sheet only .156″ in thickness below the tank center line and .125″ thick above.

This unit permits a tremendously increased payload, with the additional features of a cooler cargo because of higher sun-heat reflectivity, and a much greater capacity to disperse heat from defective brakes or similar sources of danger. It typifies the advantages gained by use of sheet aluminum in appropriate applications.

Diversities of alloy, temper and cladding provide aluminum sheet material for almost any purpose. Yield strengths of aluminum sheets range from about 5000 psi in the pure, untreated materials to about 75,000 psi in heat treatable alloys. The latter figure will be recognized by designers as superior to that of many steels. Yield strengths in the neighborhood of 20,000 to 30,000 psi are common to many alloys, with only moderate hardening treatments.


PSI X 1,000
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
3003
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COMPARATIVE TYPICAL YIELD STRENGTH OF ALUMINUM ALLOY SHEET IN VARIOUS TEMPERS

Frequently, the designer in aluminum encounters applications in which he would prefer to use a basic metal of high strength, but with a surface offering especially high resistance to corrosion. For such purpose, "clad" aluminum materials have been developed and are widely used. These sheets are prepared by rolling together the desired alloys to create a dependable and permanent bond. Aluminum sheeting may be clad both sides, and may be obtained clad on one side only by special inquiry, and is offered in both flat and tubular forms.

For applying decorative effects to aluminum parts, many and varied finishing processes have been developed. Perhaps the best known is anodizing, an electrical treatment by which a film of oxide is formed suitable for dyeing in a wide range of colors. Electroplating with other metals may be applied readily, as may numerous types of chemical etching and coating. Satin finishes and other soft-reflection surfaces may be attained by mechanical abrasion or tumbling. For irregularly shaped pieces, difficult to finish by ordinary means, an electro-brightening process removes surface impurities and brightens the overall effect. Paints, lacquers and varnishes may easily be applied to properly prepared aluminum surfaces, which thereafter will not be stained or discolored, as from rusting steel.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office:* Palmolive Bldg., 919 North Michigan Avenue, Chicago 11, Ill. *Executive Office:* 7577 Kaiser Bldg., Oakland 12, Calif.

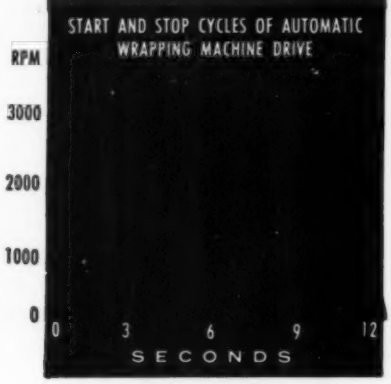
see our catalog in
PRODUCT DESIGN FILE
or write for copy

Kaiser Aluminum

setting the pace—in growth, quality and service

KAISER ALUMINUM & CHEMICAL SALES, INC.
Room 7577 Industrial Service Division • 1924 Broadway, Oakland 12, Ca
Please send, without obligation, the entire "Designing with Aluminu... ...ries" to:
NAME _____ POSITION _____
COMPANY _____ ADDRESS _____
CITY _____ STATE _____

20 ROLLS OF "SARAN WRAP" EVERY MINUTE



The Dow Chemical Company's production of "Saran Wrap" has leaped from 130,000 rolls to 4,000,000 rolls a month since 1951. This up-swing is due to a new plant, a new flow system, and additional equipment including new machinery equipped with Reliance V★S Drives.

One of the most dramatic applications of V★S Drives is on the final wrapping machines shown here. The drives must be able to start, accelerate to 3500 rpm., and stop more than 20 times a minute.

The most important feature, though, is not the frequent starts and stops, but the delicately controlled acceleration of the drives. "Saran Wrap" is only 1/6th as thick as a human hair, and sharp or jerky starts will cause a break in the sheet and halt production. Reliance Drives do the job day in and day out without a single break due to uncontrolled acceleration.

This feature of V★S Drives, called *Dynamic Response*, is only one of the many facets of Reliance Drives. V★S Drives can regulate tension, synchronize operations, control speed rates, and automatically program speed changes.

Whether you handle a thin film of plastic or steel billets, on a complete production line or a single machine, Reliance can give you better quality, more production, and lower costs through Variable Speed Drives. D-1506

Write for bulletin D-2311.

RELIANCE V★S DRIVE ®

RELIANCE ELECTRIC AND ENGINEERING CO.

CLEVELAND 10, OHIO • OFFICES IN PRINCIPAL CITIES
Canadian Division: Welland, Ontario

—ITEM 209—
For More Information Circle Item Number on Yellow Card—page 19

DESIGN AROUND THIS NEW

. . . permits motor change in minutes

Specify the New 100 SERIES for MAXIMUM HORSEPOWER PER DOLLAR *Certified* by INDEPENDENT LABORATORY tests

PATENTS PENDING

BOSTON Gear
100 SERIES
REDUCTORS

- NEW space saving design
- NEW clean contours
- NEW gearing efficiency
- NEW cooling fins
- FAN COOLING optional on larger sizes

COST-SAVING "COMBINATION"

. . . continued operation with spare

No downtime for motor repairs!

The new 100 SERIES RATIOMOTOR combines an independent gear reduction unit and an easily detachable standard end-mounted motor.

MOTOR CAN BE REMOVED AND REPLACED in a few minutes, without disturbing the gear reduction unit. Saves maintenance time, preserves alignment, permits continued operation with spare motor.

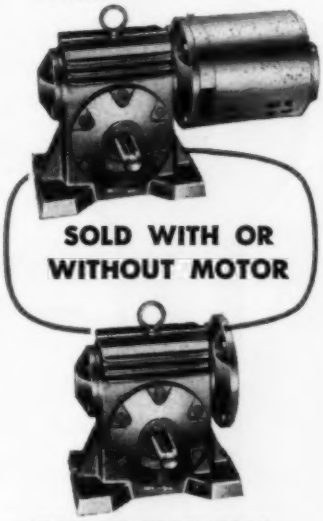
ORIGINAL MOTOR CAN BE CHANGED When conditions require change to a motor of special characteristics (totally enclosed, explosion-proof, etc.) it can easily be attached in place of the original motor.

ANY MODEL YOU NEED — FROM STOCK The new BOSTON GEAR 100 SERIES includes 1064 different units to fit any drive need. Reductors, for mechanical drives, as well as Ratiomotors and Flanged Reductors, are *standardized stock units* sold by BOSTON GEAR Distributors, located in every industrial center of the U. S. and Canada.

TALK TO A BOSTON GEAR FIELD ENGINEER Our 76-year experience as speed reducer specialists will help you simplify planning, and put your product ahead in design. Your Boston Gear Distributor will arrange a call, or write: Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

RATIOMOTORS

The complete power package. Gear unit has fin-cooling and other high efficiency features of new 100 Series Reductors.



FLANGED REDUCTORS

The Ratiomotor gear unit, supplied without motor. You buy and attach any standard end-mounted motor of your own choice.

Call your **BOSTON** *Gear*® **DISTRIBUTOR**

For nearest Distributor, look under "GEARS" in the Yellow Section of your Telephone Directory.

108 MODELS — 1064 DIFFERENT UNITS — FROM STOCK

GET NEW CATALOG R-56

Lists models for any drive . . . horizontal or vertical — right angle or parallel — single or double reduction. Includes handy selection charts, engineering data.

55-BG-R-17

—ITEM 210—

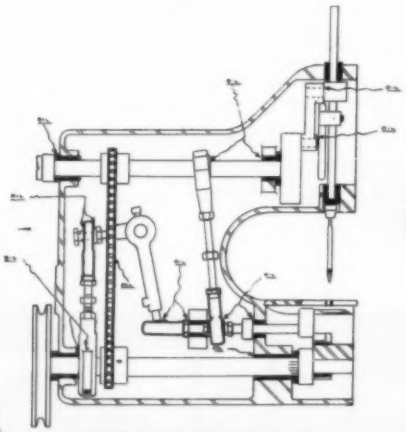
For More Information Circle Item Number on Yellow Card—page 19

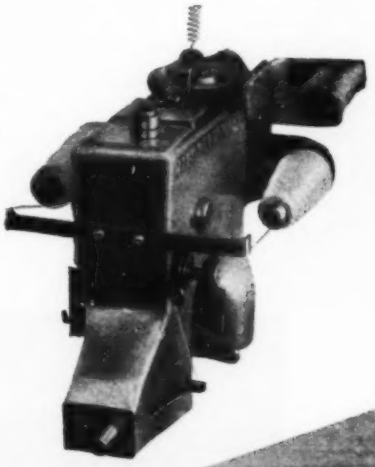
Misalignment to 25°

easily handled by HEIM *Unibal* ROD ENDS

The Heim Unibal Bearing consists of a single ball oscillating in a bronze bearing race housed in solid steel. The ball is bored through its center to accept the shaft or stud. This construction provides an anti-friction bearing which corrects misalignment in all directions.

In designing the model H-150 Portable Sewing Machine, the Minneapolis Sewing Machine Co. used three Heim Unibal Rod End Bearings in the linkage to take care of a 25° operating misalignment. On the several thousand H-150 machines in operation all over the country, Heim Rod Ends have proven highly satisfactory under every condition. This versatile Minneapolis Sewing Machine not only handles all bags (cloth, paper, and multiwall), but will sew over wrinkles, bag gathers and other impediments.





Wherever motion must be transmitted at odd and varying angles, you will find that Heim Unibal Rod Ends give maximum performance at low cost. Would you like a sample Unibal bearing?

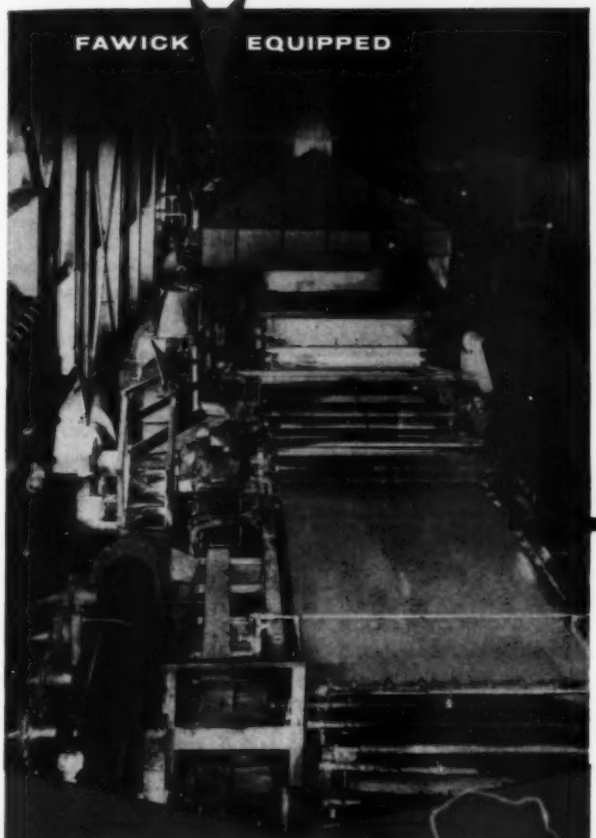
A COMPLETE CATALOG? PLEASE WRITE . . .

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

—ITEM 211—
For More Information Circle Item Number on Yellow Card—page 19

XUM

FAWICK Products in Action
IN THE PAPER INDUSTRY



One of the seven paper machines in operation at Hammermill Paper Company, Erie, Pa.

Typical Fawick Airflex Clutch installation on a Line Shaft Drive for paper production at Hammermill.

HAMMERMILL reports: *FAWICK clutches reduce costly "downtime"!*

The men responsible for continuous production at Hammermill prefer FAWICK Airflex Clutches on their paper machines.

FAWICK Clutches require practically no maintenance, and at Hammermill have helped eliminate costly downtime periods. In addition, FAWICK units provide the positive, smooth finger-tip control vital to paper machine operation.

The outstanding and performance-proved operating characteristics and service life of FAWICK products on all types of industrial machines have proved that "it works best when FAWICK-EQUIPPED".

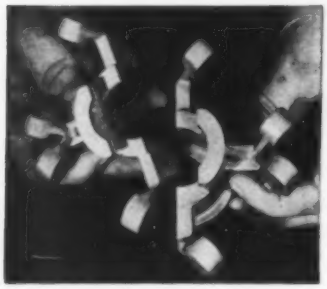
FAWICK engineers in Cleveland and in the field will gladly show you the advantages FAWICK products will provide on your equipment. A call or letter will bring all information to you.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada Ltd., Toronto, Montreal

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

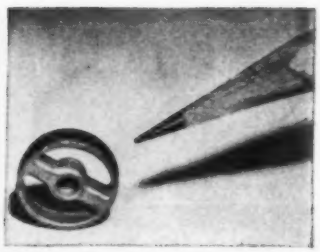
1. Cut costs up to 60%

When precision cast by Inco, these two trigger parts of a powder-actuated fastening tool cost the tool manufacturer *half* what they would have cost if machined from bar stock. *Instead of twenty machining operations he makes only two!*

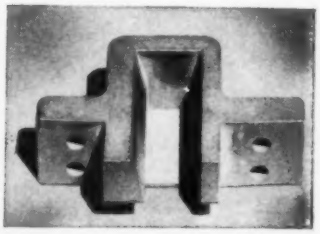


2. Wider design latitude Formerly, made in six parts, this stabilizer collar for a sonar device had to be assembled with screws. Inco precision casts it in *two parts*, simplifying and improving the design, cutting cost with fewer production and assembly steps.

3. Little or no machining required A milk-bottle capping machine has 6 of these stainless steel wedges. Once, each took 13 machining operations (more — counting rough and finish cuts). When precision cast by Inco, each needs only 9 machining operations — four of them light, finish cuts. *Net saving in machining time is 75%.*



4. Higher alloys at lower cost To protect color and flavor, the manufacturer of a liquor dispensing system wanted to make this collet head of Inconel* nickel-chromium alloy. Machined from bar stock, it needed 10 operations (and half the bar ended as scrap). Now, Inco precision casting makes the use of Inconel alloy practical, *cuts cost 30%.*



5. Longer life with harder alloys This latch for a commercial laundry machine must be strong and hard, resist galling and corrosion. "S" Monel* hard-grade nickel-copper cast alloy seemed the logical choice, but all the forging, broaching, soldering, drilling and facing ruled it out. However, Inco precision cast the latch so only finish machining is needed. Now, this alloy is practical to use.

Got a tricky small part?

...*Inco Precision Casting offers* 5 Big Advantages

Do you have a part which is 6 inches by 5 inches or smaller? Does it weigh under 3 pounds? Require starting tolerances as close as plus or minus .005 inch per linear inch? And need 5 or more fabrication steps? If the answer is *YES*, down the line, there's a good chance you can cut costs drastically, and achieve design advantages at the same time, by having it *precision investment cast* by Inco.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

Get This Helpful New Booklet

Trying to keep costs in line on some small part? Then write for new 16-page booklet, "Cast to Outlast." Contains many case histories detailing how others cut costs with Inco precision casting. There is a good chance this helpful data will suggest a practical way to cut your costs, too.

*Registered trademark of The International Nickel Company, Inc.

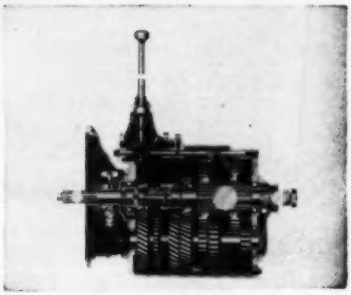
INCO TRADE MARK

Inco Castings *Precision • Sand • Centrifugal*

—ITEM 213—

XUM

YELLOW TRANSIT adds 200 new Fuller Transmissions



Model 5-A-65 Transmission

Yellow Transit Freight Lines, Inc. of Kansas City, Missouri, recently purchased 200 new cab-beside Kenworth Tractors for their 8,435 miles of certified routes through 8 midwestern states.

Powered by 175 hp turbo-supercharged diesel engines, these tractors are equipped with Fuller 5-A-65 heavy-duty 5-speed Transmissions. These Fuller "direct in fifth" Transmissions with constant mesh helical gearing in the top three speeds, were chosen because of their excellent performance for Yellow Transit in the past.

Says William R. Riley, Yellow Transit's Superintendent of Maintenance: "We have used Fuller Transmissions for a number of years. Our satisfactory experience guided us in the selection of these transmissions for the new Kenworths."

Fuller Transmissions let the driver select the ratio he needs at the *right* time to meet every varying condition of time, traffic and terrain. See *your* local truck dealer today. Ask him for the most efficient, easiest-shifting Fuller Transmission to meet your trucking requirements.

Fuller TRANSMISSIONS

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO, MICHIGAN

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

—ITEM 214—

BLOOD BROTHERS helps solve another UNIVERSAL JOINT problem...

WHAT'S **NEW** AT BLOOD BROTHERS

PROBLEM: A well-known product engineering firm, designing a specialized mobile, diesel-driven machine, required special universal joints to transmit power to rubber-tired all-steering wheels. Joint length and diameter were limited by unusual space restrictions, yet heavy torque loads were expected at angles to 30°.

ACTION: As the designers had worked with Blood Brothers on universals for the unit's conveyor, they sent us experimental joints previously handmade for a larger machine.

SOLUTION: After study of the problem, Blood Brothers' engineers proposed certain alterations, resulting in production and tooling savings.

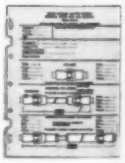
RESULT: Customer-supplier cooperation helped produce a non-standard joint which successfully meets both cost and operating conditions.

Very likely, your needs can be met with standard components, as Blood Brothers builds more types and sizes of universal joints than any other manufacturer. But standard or special, our engineers are willing and able to cooperate with you. Just write or call.

FLANGED STRAP-YOKE JOINT

In contrast to the heavy-duty joint above, it suggests the wide range of types and sizes offered by Blood Brothers.

For your convenience in specifying requirements, write for copies of this Blank Form "Specification Sheet". They're free!



BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY

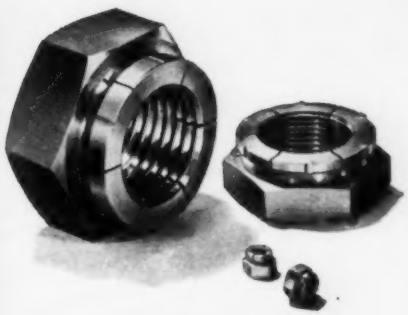
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

—ITEM 215—

For More Information Circle Item Number on Yellow Card—page 19

PHILADELPHIA TRANSPORTATION COMPANY, Philadelphia, Pa., uses FLEXLOC Self-Locking Nuts on the rear axle flanges of its buses. This carrier has found that FLEXLOCs eliminate sheared studs, reduce maintenance, save time and money.



How FLEXLOC locknuts work

FLEXLOCs lock and stay put on a threaded member regardless of the vibration encountered. Here's how they work. The slotted top or locking section is divided into six equal, flexible segments, closed in to make the inside diameter of the nut smaller than that of the companion bolt. When the FLEXLOC is applied, these are expanded by the bolt. The spring tension of the resilient segments locks the nut securely at any desired position on the bolt once the locking threads are fully engaged.

FLEXLOCs can be used over and over again. When expanded by the bolt, the locking section remains within the elastic limit of the metal. This permits the locking segments to return to their normal position, ready for reapplication to the bolt.

FLEXLOCs are one piece, all metal—nothing to assemble, come apart, lose or forget. They can be delivered in any quantity in a wide range of sizes. Stocks are carried by industrial distributors everywhere. Write for literature and samples. SPS, Jenkintown 18, Pa.

See us at Booth 479—ASTE Show

FLEXLOC®

LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

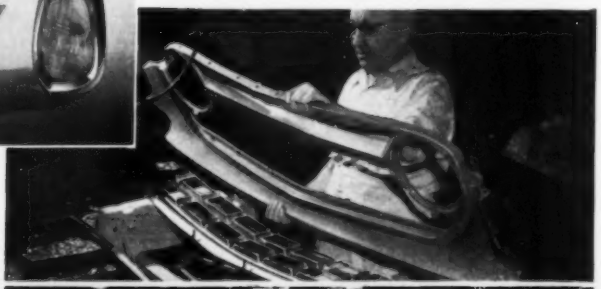
—ITEM 216—

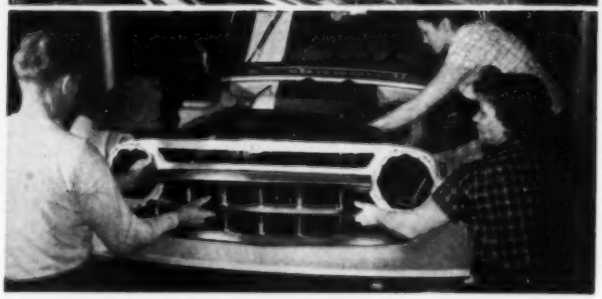
NUMBER 1 OF A SERIES

PRODUCTION SHORT CUTS WITH

ZINC

DIE CASTINGS





The RAMBLER puts on its best front!

The completely new 1956 Rambler—by American Motors—features a unique front end assembly styled to endow this compact, economical car with a massive, forward-thrusting look. And this assembly graphically illustrates why ZINC Die Castings are so widely specified by design engineers in and out of the automotive industry.

As you see, the ZINC Die Cast grille is attached to a sheet metal frame before mounting on the car. The grille top molding and the inboard headlamp bezels are then attached to cover the frame and complete the front end. Because such unusual shapes can be die cast, only four castings are required in the assembly (plus the two running-light bezels in the fenders).

Send for your copy

The Rambler front end assembly is further simplified by casting the steel mounting bolts as inserts in the back of both the grille and the molding. These precisely located fastening elements, plus the overall dimensional accuracy of the castings, assure perfect fits every time. Add easy finishability (all of the castings are beautifully chromium plated) and you have the principal reasons why ZINC Die Castings are specified by American Motors engineers.

For possible answers to *your* particular production problems, send for our brochure and contact any commercial die casting company.

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front St., New York 38, N. Y.

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

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MACHINE DESIGN
MARCH 22, 1956

Climate for Creative Design

EIGHTY-THREE per cent of engineers are satisfied with working conditions in their present jobs, according to a recent survey. This may seem gratifying to employers, but what of the 17 per cent who are dissatisfied? They are among the ones most likely to answer classified advertisements and to accept job offers from other employers.

Providing a good place to work therefore becomes a significant factor in controlling turnover of engineering personnel.

A man spends almost half of his waking hours on the job, traveling to and from work, and lunching at or near his place of work. The pleasantness of modern "gracious living" in which he spends the other half inevitably will be contrasted with his environment at work.

Fortunately an engineer's pride and satisfaction in doing a professional job hold his interest in spite of surroundings necessarily less attractive than his home.

Nevertheless, smart employers are going out of their way to provide for their engineers a physical environment favorable to creative effort. Ample space, good lighting, effective ventilation and freedom from noise or undue distraction are prime essentials. Modern, high-quality office furniture and equipment should be — but are not always — given top consideration. Often overlooked or considered unnecessary is provision of adequate clerical, stenographic and even telephone service.

If an engineer arrives in the morning irritated by parking difficulties, how long will it take him to calm down and give his full mind to the job? Or if he has to eat an indifferent lunch in unappetizing surroundings will he return to the job refreshed and relaxed as he should be? Consideration of such things can pay off in improved employee attitude and performance.

Facilities that were satisfactory a decade ago may no longer satisfy today's engineer. Management dare not wait for its engineers to succumb to the lure of "sunny California" or "smog-free Long Island." The time to modernize the engineers' surroundings is now.

Colin Carmichael

EDITOR

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Factors to consider in

Lighting an Engineering Department

- Visual requirements
- Quantity of light
- Quality of light
- Light sources
- Lighting systems
- Application techniques
- Lighting maintenance
- Cost

By John J. Neidhart
Lighting Engineer
Westinghouse Electric Corp.
Cleveland

MANY factors contribute to efficient operation in engineering offices and drafting rooms. One that is sometimes overlooked or not given adequate consideration is lighting. Yet light is perhaps the most important work aid engineering department personnel have. Engineering jobs require careful visual discrimination of fine details, usually for prolonged periods of time. Not only is an adequate amount of illumination essential for clear and accurate seeing, but the nature of the work also requires special attention to visual comfort.

Lighting Quantity and Quality

A sufficient amount of light is a major requisite in engineering departments because in these areas drawings or prints are studied, detail drawings are made, and other difficult visual tasks are performed, *Fig.* 1, Recommended values of illumination for various seeing tasks, *Table* 1, require at least 50 footcandles for most engineering-department work.

Considerably higher levels are often desirable if visual comfort can be maintained. The combination of fine details and low contrast found in many drawing reproductions, design notes and calculations can usually be seen easier with high levels of illumination. Also, illumination on vertical surfaces in a room is usually only ½ to ⅓ the horizontal work-plane illumination. Thus, 100 to 150 footcandles on horizontal work surfaces

Table 1—Recommended Illumination Levels

Type of Seeing Task	Illumination on Work Surfaces (ft-c)
Difficult ..... Work involving discrimination of fine details (6 to 8-point type) and poor contrast (lightly penciled lines) done for prolonged periods of time. Includes areas where office and calculating machines are used, where drafting and designing is done, and notes are transcribed.	50
Ordinary ..... Work involving discrimination of moderately fine detail (8 to 12-point type) and better than average contrast (inked lines or typewritten copy on white paper) done for intermittant periods of time. This category includes conferring, interviewing, reading, active filing, etc.	30
Casual ..... Inactive file rooms, stairways and escalators, and hallways and corridors.	10

From the 1956 Illuminating Engineering Society *Recommended Practice for Office Lighting.* Recommendations consider difficulty of various seeing tasks and current general cost of lighting. Higher illumination values are desirable when practicable since they will, under proper environmental seeing conditions, result in more efficient visual performance.

The lighting level should be maintained in service through proper cleaning of lighting equipment, replacement of depreciated or failed lamps, and cleaning or painting of room surfaces. Initial values will have to be sufficiently greater than recommended to compensate for expected lighting depreciation.

Fig. 1—Drafting-room lighting system using semi-indirect fluorescent luminaires. Each lighting unit contains two 40-watt lamps and is suspended 18 inches below a 9-foot ceiling

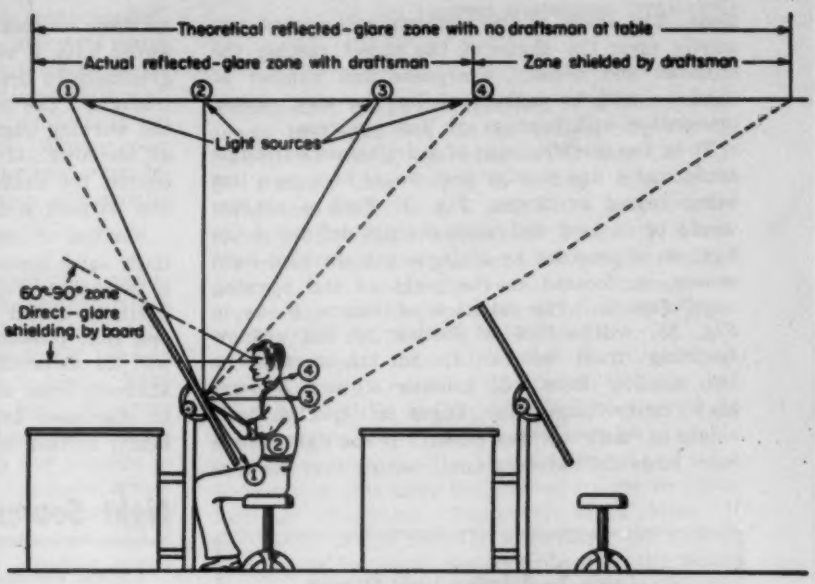

Fig. 2—Effects of drafting-board position on direct and reflected glare. Vertical board positions tend to minimize shadows, shield luminaires from view, and direct reflections of light sources below eye level

may be required to obtain the recommended 50 footcandles on vertical or nearly vertical drafting boards, *Fig.* 2, note transcribers, computer control panels, etc.

Lighting systems are frequently designed only to provide the desired illumination level and to satisfy someone's aesthetic requirements. Lighting quality considerations, which include seeing comfort, freedom from annoying shadows, and illumination uniformity, cannot, however, be neglected. Many of the benefits that should be expected from a high illumination level may be lost if it is accompanied by glare or harsh, annoying shadows.

Direct Glare: Creation of a comfortable seeing environment entails the elimination of annoying direct glare and the minimization of brightness differences throughout the visual field. Direct glare might be described as light out of place. It results when inadequately shielded light sources or overly bright luminaires occupy a significant portion of the field of view. It may cause physical discomfort, leading to headaches and eyestrain; or its effects may be more subtle by forcing the eyes to operate less efficiently, resulting in general fatigue.

The need for minimizing brightness differences between large areas in the visual field should be recognized. For example, a luminaire will be more glaring when seen against a dark ceiling or wall than against a light surface just as the headlights of an approaching automobile are glaring at night but are not annoying by day. Also, as the eye moves about the visual field, it automatically tries to adjust or adapt itself to each different brightness it sees. Extreme brightness differences keep the visual adaptation process in a state of turmoil which can result in fatigue.

Reflected Glare: An insidious form of glare is reflected glare, which results from the reflections of bright light sources by shiny surfaces. If the shiny surface is part of the visual task (tracing cloth, for example), the reflection will have a veiling effect which obscures the details to be seen. If the shiny surface is adjacent to the task itself (drafting instruments or a glass desk top), the reflection will be distracting and annoying. Here again, eye muscles will be unnecessarily forced into action, because the eye will alternate between focusing on the task, which might be at a viewing distance of 14 inches, and focusing on the reflection, which effectively might be 14 inches plus the distance from the shiny surface to the light source.

Shadows: Strong, well-defined shadows are undesirable in any office, but they can be particularly vexing in drafting rooms. Harsh shadows result when much of the light on the task comes from relatively small sources in a few scattered loca-

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tions. The shape of the shadows will depend primarily upon the shape of the object casting the shadow; and density, sharpness and number of shadows will be influenced by the size, shape, orientation and location of light sources.

Thus, the working edge of a draftsman's triangle could cast a line shadow that would obscure a line being traced or drawn, *Fig.* 3. Such a shadow would be darkest and most sharply defined if the light were provided by a single concentrated light source, *A*, located to the right of the working edge, *Fig.* 3*a*. The addition of source *B*, as in *Fig.* 3*b*, will soften a portion of the shadow resulting from source *A*, but there will be two shadow lines. If sources *A* and *B* were each fairly large, the edges of the shadows would be "soft" or "feathered." If the light source were large and extended continuously over the area between sources *A* and *B*, the resulting shadow would have a very soft edge and would increase gradually in density approaching the edge of the triangle. The addition of sources to the left of the working edge would soften, but not eliminate, all shadows. If the entire ceiling were the light source, the shadow would be very light in density and without a definable edge.

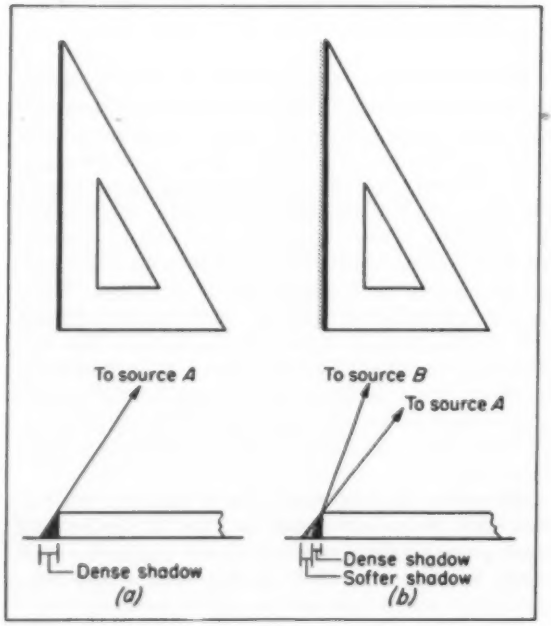
Vertical or nearly vertical drafting boards partially solve some of the lighting problems previously discussed. *Fig.* 2 demonstrates that such boards partially shield the luminaires from direct view and that possible reflections of the light sources will be directed below eye level. The effect of shadows from direct lighting systems, which will be discussed later, will also be minimized with nearly vertical board positions.

Table 2—Relative Light Output of Fluorescent Lamps

Lamp Color Designation*	Light Output (per cent)
Standard cool white	100
Deluxe cool white†	75
White	103
Standard warm white	103
Deluxe warm white†	78
Daylight	92
Soft white	76

*These lamp colors are available from all major manufacturers of fluorescent lamps although some use slightly different designations.
†Deluxe lamps provide excellent color rendition with a sacrifice in light output.

Fig. 3—Shadow effects which may be produced along the working edge of a triangle or straightedge by a single concentrated light source, *a*, and by two such sources, *b*

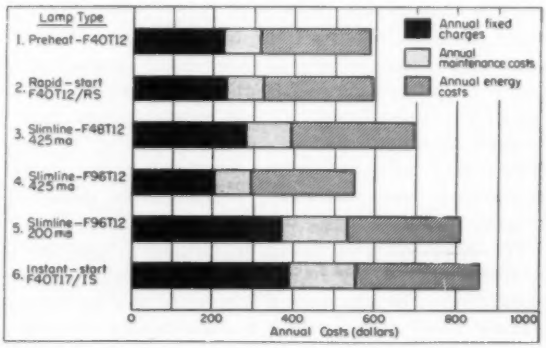


Light Sources

Except for inactive file rooms and some service areas or where only dc power is available, the incandescent lamp is now seldom used for new installations in engineering departments. The high efficiency, relatively low brightness, coolness, and diffuse characteristics of the fluorescent lamp make it well suited to satisfying the lighting quantity and quality requirements discussed previously. There is, however, a wide variety of fluorescent lamp "white" colors and types from which a selection must be made.

Lamp Colors: Of the seven "white" colors listed in *Table* 2 only three or four are used extensively for lighting engineering departments. The *standard cool white, white* and *standard warm white* are most commonly used, because they have the highest light output and good color rendition. Where a cool atmosphere from the lighting is

Fig. 4—Cost of lighting analysis for a typical office area 40 by 50 by 12 feet lighted to 50 footcandles with two-lamp direct-indirect luminaires. Annual fixed charges consist of initial cost of lighting installation amortized over 10 years with a 5 per cent allowance for taxes, insurance and interest. Annual energy cost is based on 2 cents per kilowatt-hour and 3000 operating hours per year



desired, the *standard cool white* is recommended. To achieve a warm atmosphere, the *standard warm white* should ordinarily be used. *Cool white* blends well with daylight, and *warm white* blends well with incandescent light. In effect, *white* falls between the *cool* and *warm whites*. Where color rendition is important, as in a color rendering department, the *deluxe cool white* lamp will usually be most suitable.

Lamp Types: In *Table* 3 are listed the characteristics of four basic types of fluorescent lamps —preheat, rapid-start, slimline, and instant-start. The first three types are most commonly used in engineering departments. Preheat lamps have separate starters which heat the lamp filaments a short time before full voltage is applied. Therefore, these lamps usually require a few seconds to start. Rapid-start lamps require ballasts which have special circuits for heating the lamp filaments to permit quick starting—usually in less than a second. Instant-start lamps and slimline lamps both start instantly. The basic difference between the two is that a single-pin base is employed on the slimline lamps while the lamps that are actually designated instant-start have either medium or mogul-bipin bases like preheat lamps.

A 40-watt preheat lamp is designated F40T12 (F for fluorescent, 40 for 40 watts, T for tubular, and 12 for the diameter of the fluorescent tube in eighths of an inch). The 40-watt rapid-start and instant-start lamps are specified in a similar way except that /RS and /IS are added, respectively. In slimline lamps, the number following the F is the nominal lamp length in inches. High-output rapid-start lamps in 4, 6 and 8-foot lengths were recently introduced which have a new type base for newly developed push-pull sockets; instead of wattage these particular rapid-start lamps incorporate nominal length in the lamp designation—F48T12/RS, F72T12/RS, F96T12/RS.

Although not listed in *Table* 3, instant-start lamps are also available in a 40-watt T12 size, but the F40T17/IS is usually specified because of its lower brightness. Preheat lamps are also available in 90-watt sizes, but the high brightness and large diameter of this lamp has limited its use in office lighting equipment. Similarly, large sizes of rapid-start lamps recently introduced will require changes in luminaire design to provide the necessary shielding for these higher-brightness sources. Hence, in the rapid-start types the 40-watt lamp is currently most commonly employed for office and drafting-room lighting. Slimline lamps are available in 4, 6 and 8-foot lengths and may be operated at 200, 425 and 600-milliampere currents to attain different light outputs. The 4 and 8-foot lengths are, however, the most popular, and the 425-milliampere current is considered standard. When op-

Table 3—Fluorescent Lamp Characteristics

Type	Preheat	Rapid-Start	Slimline			Instant-Start
Designation	F40T12	F40T12/RS	F48T12	F96T12	F96T12	F40T17/IS
Physical Characteristics						
Length (nominal), in.	48	48	48	96	96	60
Length (luminous), in.	46.5	46.5	44.5	92.25	92.25	57
Diameter, in.	1.5	1.5	1.5	1.5	1.5	2.125
Base	Med. bipin	Med. bipin	Single pin	Single pin	Single pin	Mogul bipin
Electrical Characteristics						
Lamp power consumption, w	40	40	38	74	40	40
Operating current, ma	425	425	425	425	200	400
Two-lamp ballast loss, w	15.5	17	24*	35*	30	24*
Photometric Characteristics†						
Initial light output, lumens	2600	2600	2420	5190	2910	2500
Light output per foot, lumens	650	650	605	650	365	500
Brightness, footlamberts	1980	1980	1935	1998	1120	1100
Efficiency†						
Lamp only, lumens/w	64.0	64.0	62.5	70.1	72.8	62.5
Lamp and ballast, lumens/w	53.7	52.8	47.0	56.8	52.9	48.1
Maintenance Considerations						
Rated average life in hours based on						
3 hours per start	7500	7500	7500	7500	7500	6000
6 hours per start	9400	9400	9400	9400	9400	7500
12 hours per start	12,000	12,000	12,000	12,000	12,000	9600
Continuous operation	18,750	18,750	18,750	18,750	18,750	15,000
Number of starters per lamp	One	None	None	None	None	None
Ease of handling	Good	Good	Good	Poor	Poor	Good
Mechanical strength	Good	Good	Good	Fair	Fair	Good
Lampholder and base durability	Poor	Poor	Good	Good	Good	Fair
Type of ballast available	Lead-Lag	Series	Lead-Lag or Series	Lead-Lag or Series	Lead-Lag	Lead-Lag or Series
Layout Flexibility	Good	Good	Good	Poor	Poor	Fair

*For lead-lag type ballasts.
†For *white* lamps.

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erated at 200 milliamperes, the slimline lamp closely approximates the brightness of the 40-watt low-brightness lamp. Operation at 600 milliamperes is seldom employed.

Lamp Comparison: Another factor which will influence selection of the type of lamp to be employed is relative cost. Cost comparisons are too frequently based only upon the initial cost of the equipment, but such comparisons generally lead to false impressions. A valid comparison should be based upon the annual cost of lighting. This includes the amortized cost of the installation plus taxes and insurance (fixed charges) plus the cost of maintenance and electrical energy (operating costs). Maintenance costs include labor and materials for cleaning, replacing lamps, etc.

A cost comparison for a selected group of lamps is given in the bar chart in *Fig.* 4. This analysis is based upon one particular set of conditions. Variations in such factors as energy rate, operating hours, amortization period, and maintenance may alter the relative economic factors. An analysis should be made for the specific conditions of the actual room being lighted to obtain the most accurate cost comparison.

It is impossible to draw a conclusion that any single source is best, because a luminaire designer, an architect, a lighting engineer, and a user will place different degrees of importance on the various factors that influence selection of the light source. It is possible, however, to summarize a few of the main advantages and disadvantages of the lamps mentioned in this article.

The 40-watt preheat lamp is still one of the most economical light sources. Its 4-foot length makes it easy to handle, and permits flexibility in making lighting layouts. Its chief disadvantage is that it requires starters. The bipin base has also been a source of some dissatisfaction.

The 40-watt rapid-start lamp is comparable to the 40-watt preheat lamp in characteristics and economy. It has the advantage of requiring no starter, but it operates on a series two-lamp ballast which has certain drawbacks. With a series ballast, failure of one lamp will either cause the other lamp operating from the same ballast to be extinguished or to operate at an abnormally low current. If the lamp is extinguished, the maintenance man cannot ascertain which lamp has actually failed. He is, therefore, likely to replace both the failed lamp and a perfectly good one instead of going through the trial-and-error procedure required to determine which lamp should actually be replaced.

Operating at 425 milliamperes, the 96-inch slimline lamp is the most economical of all the sources compared in *Fig.* 4. It has the disadvantages of being more difficult to handle than shorter lamps and of being less flexible in making lighting layouts. This latter disadvantage can, however, be overcome by the use of shorter fixtures employing the 48-inch slimline lamp. This 4-foot lamp is easier to handle and to adapt to layouts, but its lower efficiency makes its use more costly overall. Both of the slimline lamps have the advantages of instant starting without starters and a sturdy, single-pin base that simplifies lamp replacements.

To obtain lower source brightness, any of the slimline lamps can be operated at 200 milliamperes, and data for the 96-inch lamp so operated is shown in *Table* 3 and *Fig.* 4. A similar brightness can also be obtained with a 40-watt, T17 instant-start lamp. *Fig.* 4 shows that there is an economic penalty of almost 50 per cent when the slimline lamp is operated at 200 milliamperes to minimize glare instead of 425 milliamperes. The 40-watt instant-start low-brightness lamp has a slightly greater economic disadvantage.

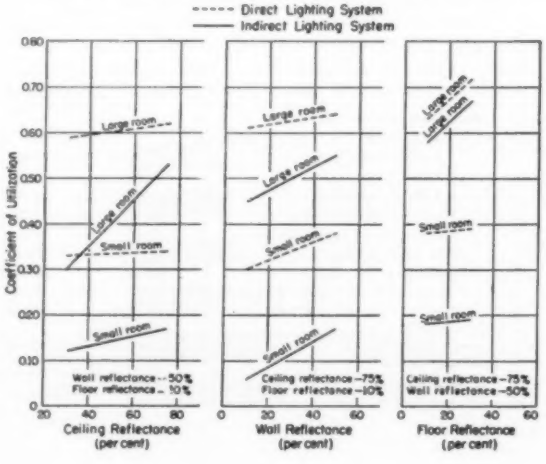
One important point to remember is that luminaires are designed to operate only one lamp type properly. Therefore, care should be exercised in selecting the most suitable lamp from all standpoints.

Lighting Systems

Electric lighting systems may be classified into five types—indirect, semi-direct, general-diffuse or direct-indirect, semidirect, and direct. The systems are defined in terms of percentages of upward and downward light.

Indirect: Lighting systems classified as indirect are those which direct 90 to 100 per cent of the light upward to the ceiling and upper sidewalls. In a well-designed installation the entire ceiling becomes the source of illumination, and annoying shadows such as those illustrated in *Fig.* 3 will be eliminated. Also, since the luminaires direct very little light downward, both direct and reflected glare will be minimized if the installation is well planned. Luminaires whose brightness approxi-

Fig. 5—Effects of ceiling, wall and floor reflectance values on coefficient of utilization of light in a room. A small room is assumed to have a luminaire mounting height about equal to room width whereas in a large room, width of the room is assumed to be three to four times the mounting height



mates that of the ceiling have some advantages in this respect. It is also important to suspend the luminaires a sufficient distance below the ceiling to obtain reasonable uniformity of ceiling brightness without excessive brightness immediately above the luminaires.

The characteristics of indirect lighting make it admirably suited to the requirements of engineering departments—particularly drafting rooms. It is not, however, a panacea; for, like most good things, it has its disadvantages and limitations. Since with indirect lighting the ceiling and walls must reflect the light to the work plane, it is essential that these surfaces have a high reflectance as recommended in *Table* 4 and as shown by the curves in *Fig.* 5. Even then, utilization is relatively low when compared to other systems of lighting and thus it is more expensive. Care must also be exercised to prevent overall ceiling brightness from becoming too high and thus glaring; this will seldom be a problem for illumination levels within the ranges recommended in *Table* 1. Indirect lighting must be used with considerable discretion at ceiling heights below 10 feet. Some object to the appearance of luminaires suspended from ceilings that are only 10 or 12 feet high, but satisfying the seeing requirements should take precedence over appearance.

Semi-Indirect: Lighting systems which emit 60 to 90 per cent of their output upward while the rest is directed downward are defined as semi-indirect. The characteristics of semi-indirect lighting systems are similar to those of indirect systems except that the downward component of light usually produces a luminaire brightness that closely matches that of the ceiling. However, if the downward component becomes too high, direct or reflected glare may result. An increased downward component improves utilization of light somewhat over that of indirect lighting. This factor makes somewhat higher illumination levels possible with fewer semidirect luminaires and without excessive ceiling brightness.

Since semi-indirect luminaires can incorporate most of the advantages of indirect luminaires with features that minimize the limitations of the latter, they are widely used for lighting drafting rooms and offices where shadows and reflected glare must be minimized. Semi-indirect luminaires such as shown in *Fig.* 1 provide up to 75 footcandles without discomfort, and they may be used with discretion on ceilings as low as 9 feet.

General-Diffuse and Direct-Indirect: When downward and upward components of light from luminaires are about equal (each 40 to 60 per cent of total luminaire output), the system is classified as general-diffuse. Direct-indirect is a special category within the classification for luminaires which emit very little light at angles near the horizontal. Since this characteristic results in lower brightnesses in the direct-glare zone, direct-indirect luminaires are usually more suitable than general-diffuse luminaires which distribute light about equally in all directions.

Although efficiency of light utilization is generally very good with these systems, the increased percentage of downward light causes more notice-

Table 4—Recommended Surface Reflectances for Offices

Surfaces	Reflectance Values		
	Minimum (per cent)	"Center-Point" (per cent)	Maximum (per cent)
Ceiling finishes*	80	80	92
Walls	40	50	60
Furniture	26†	35†	44†
Office machines and equipment.	26†	35†	44†
Floors	21	30	39

*Recommended reflectances are for finish only. Overall average reflectance of acoustic materials may be somewhat lower.

†From *American Standard Office Reflectances* Z2.1.3, 1954; UDC 535.312:651.2.

Fig. 6—Direct-indirect lighting installation. Luminaires have cellular louver bottoms and dense, diffusing-plastic side panels to shield lamps from direct view and control luminaire brightness

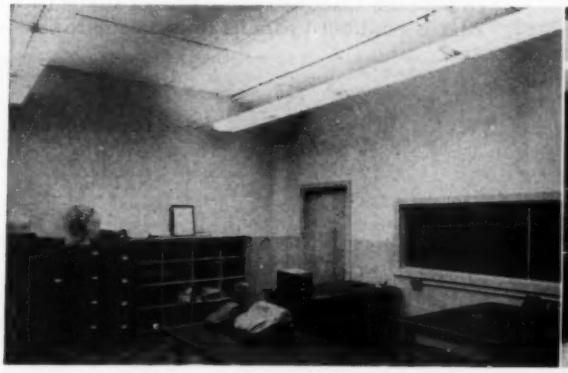


Fig. 7—Recessed-troffer direct lighting system. High values of ceiling and floor reflectance permit efficient utilization of light. Recessed troffers are usually most comfortable when viewed perpendicular to row axis

able shadows than would be inherent with the two systems previously described. Lamps must be well-shielded to prevent uncomfortable direct glare, and high-reflectance, matte (not shiny) finishes as recommended in *Table* 4 must be used on all furniture and office machines to minimize reflected glare.

Direct-indirect luminaires are satisfactory for many office areas and are currently popular because they combine good utilization of lamp light output with some of the diffuse qualities of indirect lighting. When carefully selected and applied, they can provide illumination levels of 75 to 100 footcandles without introducing visual discomfort. A typical installation of direct-indirect luminaires is shown in *Fig.* 6.

Semidirect: Luminaires which direct 60 to 90 per cent of their light output downward are classified as semidirect. The 10 to 40 per cent upward component provides ceiling illumination which increases diffusion and reduces the brightness difference between the luminaire and ceiling.

The predominantly downward light component will increase the shadow problem. The annoyance of shadows can be reduced by designing the installations so that the light at any work point comes from many directions. The use of large-area sources also helps soften shadows. Reflected glare can be minimized only by the use of high-reflectance matte finishes on furniture and office machines or by locating luminaires with respect to the work so that reflections will not be directed toward the eye.

Direct: When luminaires direct 90 to 100 per cent of their output downward, they form a direct lighting system. Disturbing shadows may be produced by such luminaires unless they are large in area or are closely spaced. To prevent direct glare and excessive brightness differences between luminaires and adjacent ceiling areas, such luminaires must be carefully selected and applied, and all room and furniture surfaces must have a high reflectance. The luminaire should be designed to shield the lamps from all possible angles of direct view.

The effect of light output per unit area of the lighting equipment should also be considered. Closely spaced lamps in a relatively small luminaire (for example, a 1-foot wide troffer) produce high overall luminaire brightness and its consequence—glare. The use of high-reflectance matte finishes on furniture and machines is especially important for the prevention of annoying reflected glare when direct lighting systems are employed. A typical direct-lighting troffer system is shown in *Fig.* 7.

Luminous ceilings, louverall ceilings, and large-area modular lighting elements are forms of direct lighting having characteristics similar to those of indirect lighting. These forms of lighting are frequently used to obtain illumination levels materially exceeding those recommended in *Table* 1, but care must be taken to limit the brightness of the shielding medium to 250 footlamberts or less to prevent direct glare. Reflected glare may be a problem with systems employing cellular louvers as the shielding medium since the images of the light sources above the louvers may be reflected by shiny surfaces at the work plane.

Lighting System Comparison: In selecting the lighting system to be employed for a given application, the characteristics of the system should be matched to the requirements of the application. The system should first of all meet the basic needs of a comfortable environment. Although the lighting installation should be in keeping with the architecture and decorative design of the office, appearance should be a secondary consideration.

Indirect or direct lighting systems which occupy all or nearly all of the ceiling area are usually characterized by minimum direct and reflected glare, good diffusion and freedom from shadows and, in the case of indirect lighting, low to moderate utilization. Although utilization is good with direct lighting as demonstrated in *Fig.* 5, the lighting quality required for engineering department tasks may be obtained only if precautions are taken to space the luminaires closely or to use large-area low-brightness equipment. Intermediate systems combine the characteristics of indirect and direct lighting in varying degrees depending upon the predominant component.

Lighting equipment having wide light-distribution characteristics should be employed to obtain good illumination on vertical surfaces if vertical drafting boards are employed. The system should be designed to provide the required illumination on the vertical task as stipulated in *Table* 1.

Application Techniques

Determination of the number of luminaires required to provide a desired illumination level is a simple arithmetic problem requiring only published lumen output and utilization data. The placement of the luminaires in the room, however, requires an understanding of the characteristics of the luminaires and their effectiveness in satisfying the visual requirements.

Fig. 8—Semidirect luminaires installed at a 45-degree angle with room axes to minimize occurrence of annoying line shadows along drafting instrument working edges. Such shadows appear when a straightedge is positioned parallel to luminaire rows

Continuous Rows: It is usually advantageous to install fluorescent luminaires other than the large-area modular units in continuous rows. This minimizes the apparent number of luminaires since each row appears to be a single unit, and it reduces the number of stems required for suspended luminaires. Continuous rows also reduce wiring expense, because only a few outlets are required per row since the luminaire channel can be used as a wireway.

Orientation of Rows: Orientation of the luminaire rows will depend upon the luminaire design, the predominant viewing direction of the room occupants, and the proportions of the room. Although it is desirable to select luminaires that can be viewed from any direction without discomfort, many lighting units are best viewed from either crosswise or endwise directions.

Suspended luminaires, particularly those with luminous side panels, should usually be installed in rows running parallel to the predominating line of sight or the length of long narrow rooms. If they are run crosswise, a maximum area of luminaire is presented to view and the illusion of a lower ceiling at the height of the luminaires may be created. The better appearance of suspended lighting equipment in rows running parallel to the line of sight is illustrated in *Fig.* 1.

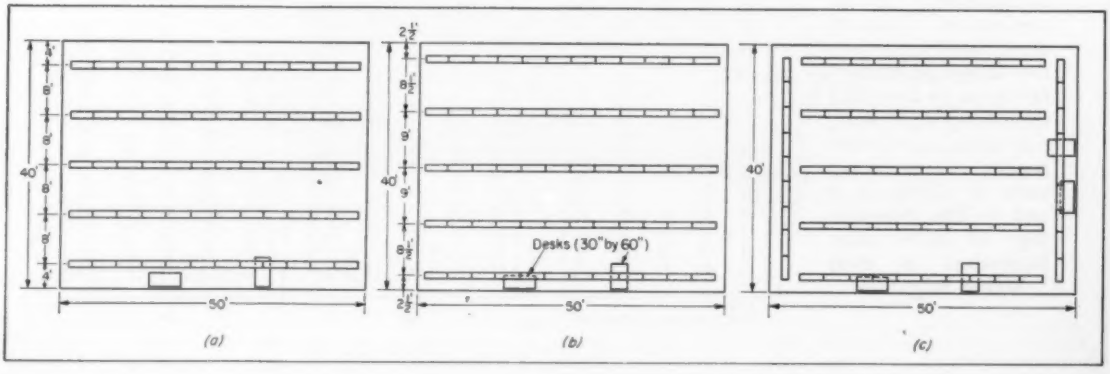
Recessed luminaires, on the other hand, are generally run across long narrow rooms or perpendicular to the predominating line of sight of the room occupants as shown in *Fig.* 7. This is especially important when the luminaire shielding medium provides good brightness control only in a crosswise direction.

Occasionally, a somewhat unconventional orientation of luminaires may be desirable. For example, in drafting rooms with horizontal boards, rows of direct or semidirect luminaires are likely to cause annoying line shadows along working edges of triangles or T-squares which are parallel to the row direction, as previously discussed. Thus, if the rows run parallel to the line of sight, shadows may be a problem when vertical lines are being drawn; if the rows are perpendicular to the line of sight, the shadow problem may be troublesome when horizontal lines are being drawn. This condition can be alleviated with a conventional lighting layout if floor space will permit locating the boards to create an angle of 15 degrees or more between the major axis of the board and that of the luminaire row. If floor space is not adequate for this, consideration should be given to a diagonal luminaire layout with the rows running at an angle of 45 degrees with the walls as shown in *Fig.* 8. With this arrangement, shadows will be a problem only for half of the 45-degree lines that are drawn—those parallel to the luminaire rows.

Spacing for Illumination Uniformity: Spacing between luminaires or luminaire rows and their distance from walls is a factor that has a major influence on illumination uniformity. Most lighting equipment manufacturers publish spacing to mounting (or ceiling) height ratios that should not be exceeded if satisfactory illumination uniformity is to be expected. Generally, the ends of luminare rows should be 6 inches to 2 feet from the walls, and the distance from the other walls to the centerline of the first luminaire (or row) should not be more than one-half the spacing between rows. Such a layout is shown in *Fig.* 9*a*.

With this arrangement, however, the illumination near the wall may be as low as 50 per cent of the illumination on work surfaces in the center of the room. If desks are to be located near or against the walls that are parallel to the luminaires, the layout shown in *Fig.* 9*b* would be preferred provided the larger spacing between rows does not exceed the maximum permissible spacing. If desks are located along the end walls, a 4-foot luminaire could be omitted from each end of each row so that an additional row could be run across each end of the room as shown in *Fig.* 9*c*. Since nine luminaires are used across the ends of the room in *Fig.* 9*c* where only five units exist in *Fig.* 9*b*,

Fig. 9—Conventional lighting layout employing 4-foot luminaires with equal spacing between rows, *a*. In *b*, layout is modified to provide more illumination on desks located against side walls. With only four more 4-foot units on each end, layout *b* can be modified to that in *c* to provide 80 per cent more light along end walls



80 per cent more light is available at each end of the room with the layout shown by *Fig.* 9c.

Sometimes, improved crosswise illumination uniformity can also be obtained by combining matched luminaires having different numbers of lamps per luminaire. For example, two-lamp luminaires may be specified for the center rows of some layouts with four-lamp luminaires along outside walls. Or, in the two-lamp troffer layout, *Fig.* 10*a*, the end luminaires of each row could be three-lamp units. These end units would be noticeably brighter than the remainder of the row; and it might be preferable to accomplish the desired result even more effectively by the technique shown by *Fig.* 10*b*. Another variation that may be employed if the row spacing permits it is shown by *Fig.* 10*c*.

Spacing for Lighting Quality: The importance of using closely-spaced direct and semidirect luminaires to minimize shadows has been mentioned previously. Close spacing of direct luminaires will also reduce the area of dark ceiling in the field of view.

For best results, the spacing between most direct luminaires should not exceed one-half the mounting height. If continuous rows are employed, this practice is likely to result in illumination levels materially exceeding those listed in *Table* 1. This recommendation is most easily followed by using single-lamp units, but the economy of two-lamp units is generally preferred. The use of three and four-lamp direct-lighting luminaires in continuous rows should be limited to small offices where the inherently low utilization of a small room will still require a close spacing between luminaires.

Large-area (2 by 4 feet or 4 by 4 feet) luminaires employing three or four lamps per unit will often produce the best results from the standpoint of lighting quality if they are individually mounted with approximately the same spacing between centers crosswise and endwise.

Crowding three or four lamps into a 1-foot wide direct luminaire or six to eight lamps in a large-area unit results in inefficiency and high brightnesses that cause direct glare. It has been found that an installation of four-lamp troffers provided no more illumination than a similar installation of three-lamp troffers. This was caused by the trapping of light by closely spaced lamps and inefficient operation of the lamps operating above their optimum temperature.

Maintenance Considerations

Every lighting installation should be designed with maintenance considerations in mind, for only the maintained "in-service" illumination level is significant. A realistic maintenance factor should be employed in the calculation of the number of luminaires required to obtain the required illumination level. This factor should recognize the susceptibility of the lighting equipment to dirt collection, the atmospheric conditions prevailing in the area, and the anticipated cleaning frequency. Without a regular maintenance program which includes prompt replacement of burned-out lamps and frequent cleaning, the illumination may be reduced to less than half its initial level.

Since the output of all interior light sources diminishes with use, it is usually economical to replace lamps before they finally fail. Lamps can usually be replaced so much more economically as a group rather than on an individual basis that savings in labor more than offset the value of the unused light output remaining in a large group of lamps nearing the end of their life. A good plan is the group-replace lamps after 20 per cent of the total have failed. The best 20 per cent of the old lamps should be saved for random replacement for the new group. When the supply of random replacement lamps is exhausted, this automatically indicates that the time for another group replacement is at hand.

Maintenance can be simplified if the lighting installations in a large department or building are designed to use only one type and color of lamp. This simplifies stocking and prevents possible confusion and improper mixing of lamps.

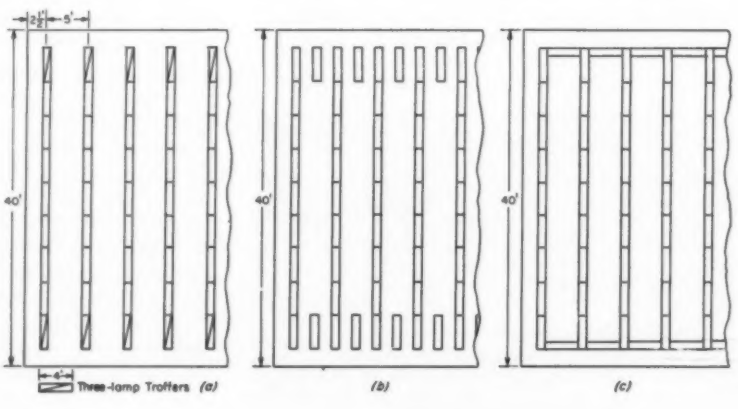
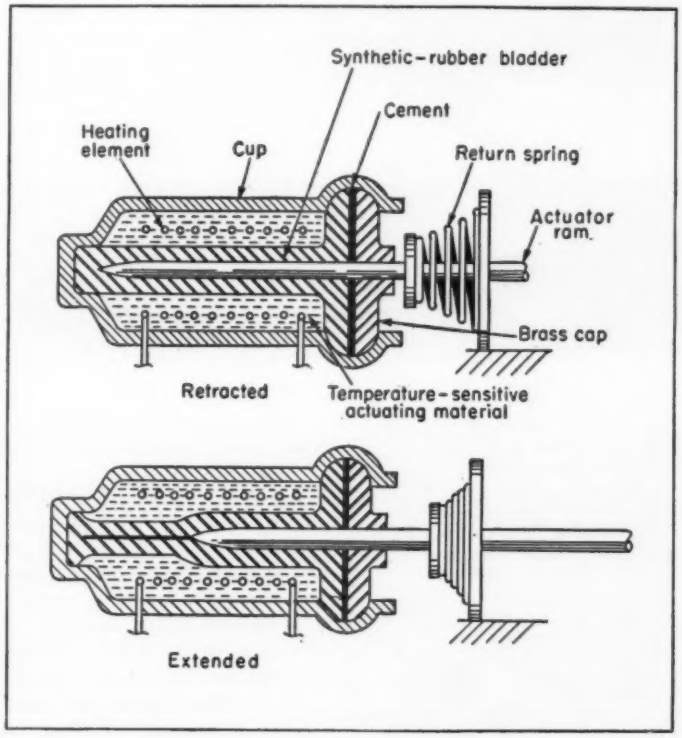
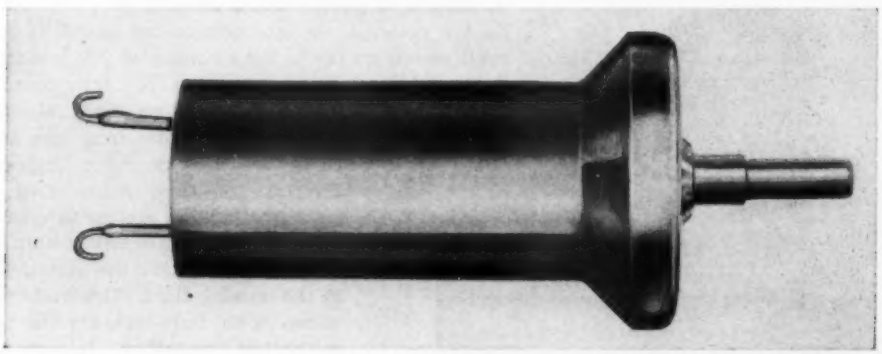


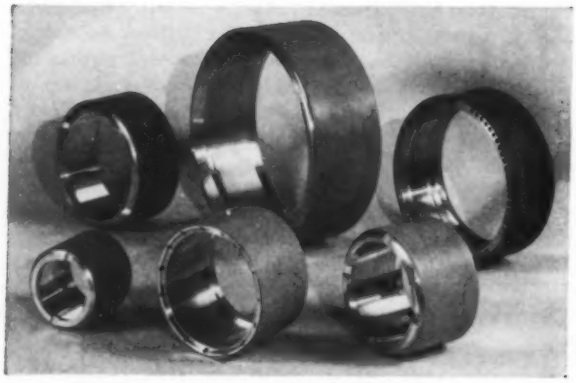
Fig. 10—Methods of compensating for illumination drop-off along side walls in a two-lamp, 4-foot troffer layout by installing three-lamp units along side walls, *a*, or by additional two-lamp units as shown in *b* and *c*. The disadvantage of three-lamp luminaires is their higher brightness

scanning the field for Ideas

HIGH THRUST FORCES in a unique linear actuator construction are produced by the melting of an inorganic material. To operate the ram, an external heat source or the heating element in the unit melts the actuating material. As this material changes from a solid to a liquid state, it expands and creates high internal forces which cause the ram to be axially displaced. When the unit is allowed to cool, the inorganic material solidifies permitting the spring to return the ram to its original position. The design was developed by Standard-Thomson Corp.

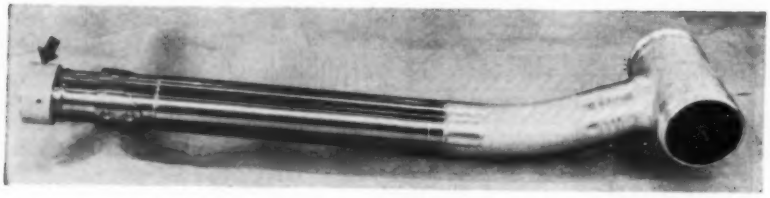


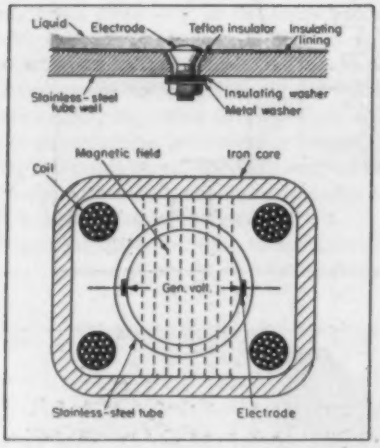




PLASTIC-CLAD METAL PISTONS for heavy-duty hydraulic applications offer high strength-weight characteristics and eliminate metal-to-metal surface contact. The pistons, which are simply metal cylinders covered with a heavy layer of thermosetting laminated plastic, tend to prevent "seizing" and resist scoring. This design was developed by the Cleveland Pneumatic Tool Co. to meet the severe service requirements of shock-absorbing struts in aircraft landing gears.

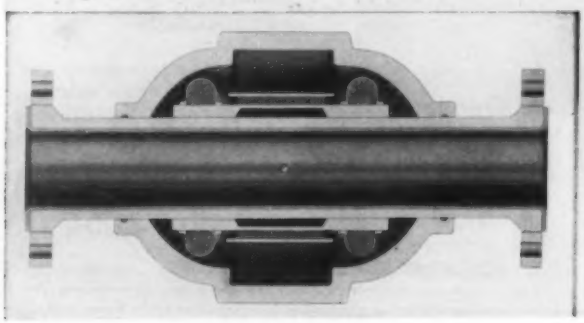
Plastic-covered metal tubes, from which the pistons are machined, are produced by a special process developed by the Synthane Corp. In the cladding technique, a continuous sheet of cotton fabric impregnated with a phenolic resin is wrapped around a 2024-T4 aluminum cylinder with a knurled surface until the desired thickness is obtained. The fabric-resin material is heated during and after the wrapping operation to achieve proper polymerization.

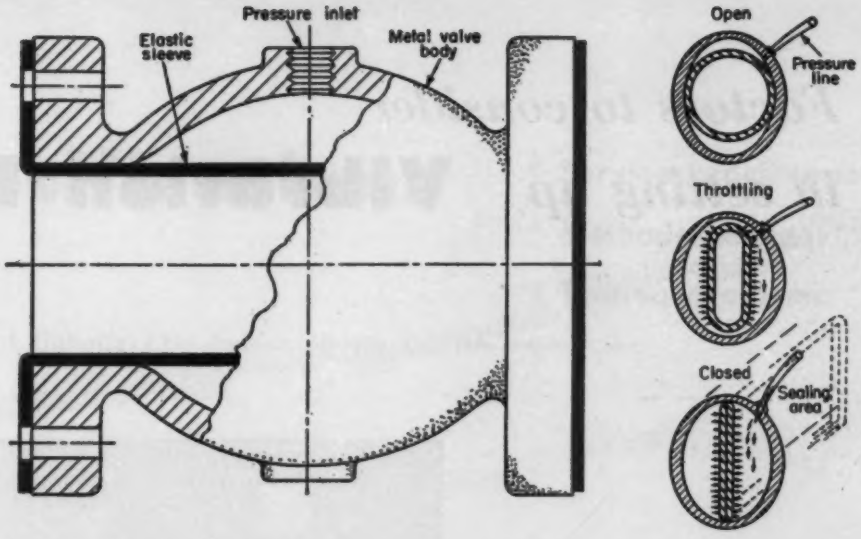




ACCURATE MEASUREMENT of liquid flow rates with minimum pressure drop in the line is accomplished electrically in Foxboro magnetic flowmeters. By this system, fluid flow is measured as it passes through a short tube with a clean, smooth bore. The technique permits measurement of volume rate of flow of liquids flowing in either direction independent of viscosity, density, turbulence or suspended matter.

The principle of operation of the meter is based on Faraday's law of electromagnetic induction: the voltage induced in a conductor of a given length moving through a uniform magnetic field is directly proportional to conductor velocity. In this design, the liquid to be measured serves as the moving conductor. A uniform magnetic field, which is produced by two coils, passes through the walls of the stainless-steel tube and the liquid. A laminated-iron core serves to focus the field at right angles to the direction of fluid flow. Two "point" electrodes, which are insulated from the tube and are made of either stainless steel or platinum, detect the voltage induced in the moving fluid. This voltage, which varies with fluid velocity, is fed to a calibrated recording instrument and translated in terms of flow rate.

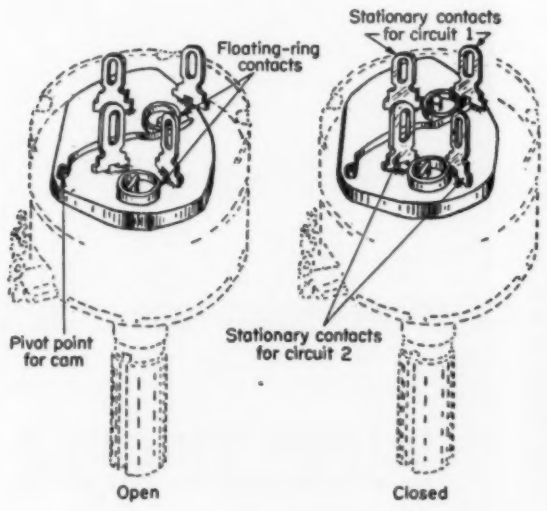


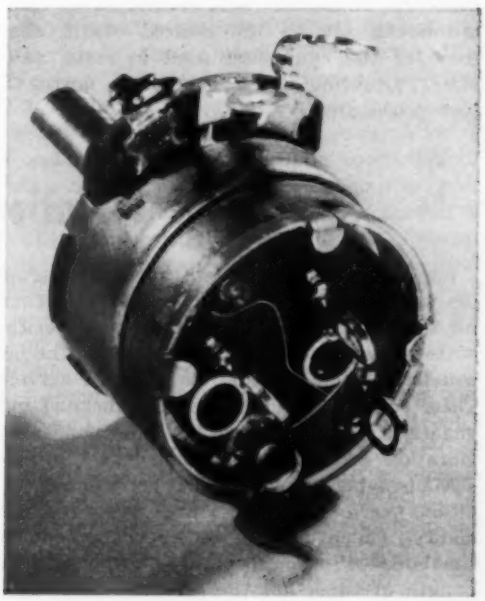


ELASTIC FLOW CONTROL in a valve designed for low-pressure corrosive fluids eliminates conventional mechanical assemblies and prevents fluid-to-metal contact. Developed by the Red Jacket Co. Inc., a flexible nonmetallic sleeve, which can be pneumatically or hydraulically pinched together, is used to provide variable flow control. Mounted in an aluminum valve body, the sleeve is made of synthetic or pure rubber and can be pulled through the valve body for replacement.

FLOATING RING CONTACTS in a snap-action switch mechanism increase power capacity, life and dependability in low-power units. Employed in switches designed by P. R. Mallory and Co. Inc., the current-carrying rings are heavily silver plated, permitting high contact pressure and reducing contact resistance and corrosion.

In operation, the rings rotate a certain amount each time the switch is actuated, and thus the areas of contact against the terminals continually change. Since the ring contacts are allowed to float in their positions on the switch rotor, positive alignment with terminals is assured.





Factors to consider in setting up **Vibration Test**

MOST PRODUCTS must endure vibration without damage or malfunction during some part of their useful lives. Vibratory conditions may be encountered during handling, transportation and storage as well as during the actual operating life of a device. As a result, vibration testing is becoming an increasingly valuable tool for improving reliability of a wide range of components and assemblies.

Primary aim of simulated vibration testing is, of course, to detect deficiencies in a product which could cause failure under service conditions. When performed with sufficient accuracy, test results permit attainment of the primary objective with no unnecessary sacrifice in size, weight, performance or cost. This article examines some of the problems connected with establishing test conditions to achieve the desired result, describes some of the equipment used in tests, and considers problems which may arise during actual test procedures.

Sources of Vibration

Simulated vibration tests attempt to duplicate the worst possible conditions of service. This calls for a thorough knowledge by the test specification writer of vibration conditions to which the product will be subjected during its expected service life. These conditions must then be translated into the quantitative parameters of vibration, such as vibration magnitude and frequency. In addition, accompanying nonvibrational environmental conditions such as temperature, pressure, and humidity, which are to be superimposed on the simulated vibration condition, must be specified. Length of time that the vibration test should be performed to reveal design weaknesses is also an essential part of the specification.

A general vibration specification applying to all components and assemblies used in aircraft manufacture, *Fig.* 1, for example, requires that they be vibrated for extended periods of time. It requires that vibration be performed both at resonant points and over a specified frequency range. Vibration specifications generally require that the vibration be applied to three mutually perpendicular axes.

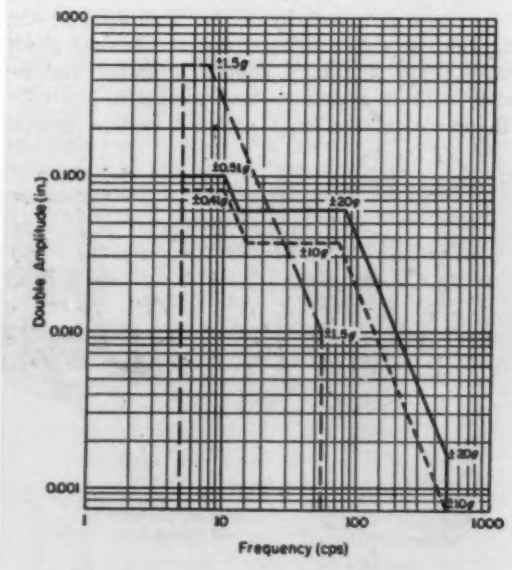
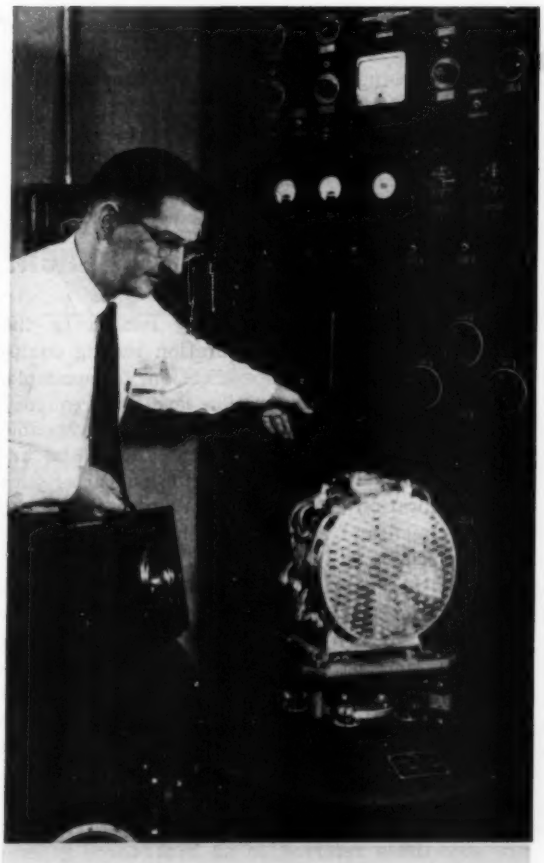


Fig. 1—Typical vibration test cycles required by military specifications for a variety of aircraft components and accessories

Specifications

- **Service requirements**
- **Methods and equipment**
- **Testing problems**

By Karl Unholtz, *Chief Engineer, MB Mfg. Co., New Haven, Conn.*



An airborne air compressor being tested with an electrodynamic vibration exciter having a force output of 600 pounds and a frequency range of 2 to 2000 cps. A stroboscope is used to observe the fan blades as they are rotating

Since vibratory force is a vector quantity, both magnitude and direction of the vibratory force to be applied to the test object must be specified. Vibration direction thus indicates both linear and rotational motions as well as the axes defining the direction of the linear motion and the centerlines about which rotations occur. Vibration magnitude is generally referred to as amplitude and describes displacement or, under certain circumstances, acceleration. Test frequencies may be a variable single frequency or a combination of frequencies applied simultaneously.

Establishing a valid test specification is made difficult by the many different conditions, encountered during handling and transporting as well as the service life of a test article, which produce vibration and shock.

Handling usually produces impact shocks due to lifting, abrupt floor contact, collision with other objects, etc. A protective container employing shock isolating means may or may not be used.

Transporting by truck imposes a combination of shock and oscillating motion. The specific characteristics of this motion depend upon road conditions, weight of the truck load, and condition of truck tires, springs and shock absorbers. Damage frequently results from large, random, vertical displacements, due to irregularities in the road surface, and the oscillatory vertical motion of the truck on its springs and tires.

Rail travel produces both steady vibration and shock loading. Steady motion results from constant irregularities in the rails, usually cyclic with rail joints. Transient oscillations occur in vertical and horizontal directions, and are due to characteristics of the car suspension and draft gear. Relatively severe shocks result from coupling and uncoupling, humping, etc.

Boat travel produces continuous, low-frequency, large-amplitude motion generated by the screw. Motion of this type can excite equipment mounted

on flexible vibration isolating mounts.

Operating conditions of the many types of aircraft are perhaps the most divergent and impose the severest design penalties. Consequently vibration problems associated with them will be taken as illustrative. Some of the major sources of shock and vibration in aircraft are:

1. Engines, both piston and turbo-propeller, and the driven propeller are major sources of steady-state vibration under constant flying conditions. Exciting frequencies as low as approximately 13 cps, and covering a wide band above this point, are generated by these sources.
2. Turbojet engines with afterburners produce vibration excitation from the turbojet as low as 60 cps, with a wide band above this frequency. In addition, a large unsteady thrust from the afterburner causes intermittent transient excitations.
3. Pulse-jet engines create major, relatively low-frequency, steady vibrations. Higher frequencies are also present.
4. Rocket engines produce an abrupt change in thrust on starting, which causes shock impulses. Also, unsteady thrust forces occur during burning and large disturbances in the audio-frequency band are present.
5. Aerodynamic forces may cause severe buffeting. They are equivalent to large intermittent forces acting on the external surfaces of the aircraft. Local turbulence can cause airfoil buzzing which, although not necessarily destructive to the surface, will cause a fairly steady vibrational disturbance. The whistling and hissing noises associated with high-performance aircraft are proof of the presence of disturbances in the audible and above-audible frequency range. Random disturbances, with large deflection, occur in flexible, large-span wings. All of these aerodynamic disturbances force surrounding structures to move. If an item of equipment is mounted on or near the aerodynamically disturbed structure, it must be insensitive to the motion imposed on it.

From this brief consideration of vibrations to which a component or assembly may be subjected, it is clear that vibration test specification can be an extremely complex problem. The problem of establishing realistic environmental test specifications can be resolved by either of two methods. An assembled unit can be tested as a whole by establishing the proper generalized force input to the complete structure and its mounted accessories. Or components of the unit can be tested individually by establishing the proper spectrum of vibration amplitude and frequency for each subassembly or component.

Starting motor of an internal-combustion engine is vibration tested while mounted on the engine. The small vibration exciter has a maximum force output of 10 pounds at frequencies from 20 to 500 cps. Total displacement of the exciter is ½-inch

Vibration Test Equipment

Test specifications are closely related to the various types of available vibration testing equipment. A vibration test specification, for example, which required an acceleration level or frequency range that could not be obtained with available or feasible vibration test equipment would be unrealistic. In addition, the dynamic characteristics of the vibration exciter may be imposed on the test specimen and make the evaluation of test results extremely difficult.

To aid in evaluating vibration test equipment, the characteristics of an ideal vibration exciter for simulation testing might first be considered. These characteristics, *Table* 1, may then be used as a common basis for comparison of the three actual types of practical vibration generators. These types are classified by the method used to generate vibration as the offset-crankpin type, rotating eccentric-mass type and the electrodynamic type.

Offset-crankpin vibration generators, Table 2, are sometimes referred to as brute-force generators. Inherently they are constant-displacement generators because crankpin offset or throw establishes fixed relative motion between the table and the machine frame. This displacement is maintained regardless of the force being transmitted to the test item.

Eccentric-mass vibration generators, Table 3, are commonly referred to as reaction type vibrators. Generated force varies in proportion to the square of the operating frequency.

If the table and mounted test article react as a rigid mass, the generated force produces a constant table displacement through the operating

frequency range. If the radius of gyration of the rotating eccentric-mass about the axis of rotation is large compared to the table motion, bearing clearances, and deflections in the bearing shaft and supports, the magnitude of the generated force will not be affected by these factors. For a given value of eccentricity and mass on the rotating shaft, the table displacement will depend upon the mass of the table and mounted test article.

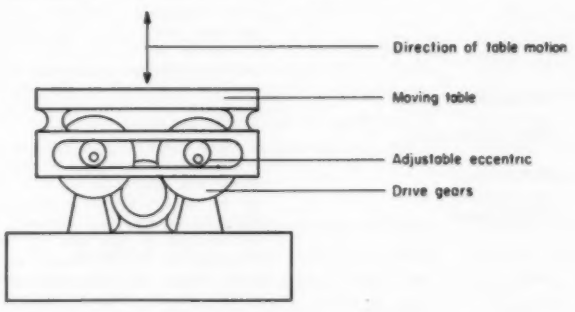
If the test article is not a rigid mass or the table and mounted test article are not rigidly connected,

Table 1—Characteristics of Ideal Vibration Exciters

1. *Wide range of operating frequencies* allows the exciter to reproduce the range of vibration frequencies encountered in many typical installations. Examination of the vibration environment of aircraft components serves to indicate the importance of this requirement.
2. *Infinitely rigid vibration-exciter table* and associated parts are desirable. If this requirement is not met, the table may depart appreciably from the desired vibration direction and magnitude at test frequencies above several hundred cycles per second. These deviations may be caused by distortion of the table as a whole or from local distortion at the points where the test object is attached. In general, the test article transmits forces and moments in all directions to the tables of both linear and torsional exciters, even though the exciting force or displacement is in one direction. Any strain in the table, therefore, will cause table motion to be different from that intended.
3. *Infinitely stiff vibration exciter table constraints* allow only the desired motion and eliminate all other freedom of motion. Vibration exciters that require table constraints to be soft in the direction of desired motion impose an additional requirement. These constraints must be massless to be free from disturbing resonances.
4. *Vibration exciter body or frame should be rigid and fixed in position* if the table constraints connect the table to the body.
5. *Precise table motion indication* should be a part of the vibration exciter.
6. *Motion both normal and parallel to the mounting plane* should be provided by the exciter. The mounting plane should be adjustable between horizontal and vertical.
7. *Pure, distortion-free harmonic motion* should be generated by the vibration exciter through the operating frequency range, regardless of the dynamic characteristics of the test article mounted on the table.
8. *A wide range of varying temperature, pressure and humidity* conditions such as might be encountered in altitude chambers should not affect exciter operation. The exciter should also perform normally in the presence of large, steady accelerations such as would be experienced on a centrifuge.
9. *Flat frequency response* allows intelligence to be fed in as a complex electrical signal and be reproduced in the displacement, velocity or acceleration waveform of the table motion.
10. *High force rating* is desirable to duplicate the highest forces to which test specimens might be subjected in actual operation.

Table 2—Characteristics of Offset-Crankpin Vibration Exciters

1. *Maximum frequency of operation* is approximately 60 cps for large-table equipment and 120 cps for small tables. The maximum frequency is limited by bearing clearances, bearing-load capacity vs. rpm, and the dynamic flexibility of moving parts. In the larger and more expensive machines, compensation is included to adjust the crankpin offset as table frequency is increased. This is necessary in order to hold constant displacement even up to 60 cps, and is intended to correct for both the mass of the moving parts of the machine and that of the test article.
2. *Table-Supporting Connections are stiff* and they eliminate static displacement of the table due to the gravity force of the table and test articles. The constant-displacement output of the table must be qualified by recognizing that attainable dynamic stiffness of the bearings, crankpins, connecting rods, and table is limited by modulus and mass considerations. To convert the relative motion between the table and its base to absolute table motion requires an exceedingly stiff and massive base. Furthermore, if the bearing clearances are not small relative to the desired table displacement a noticeable change in displacement will occur when accelerations in excess of 1 *g* are attained.
3. *Table motion direction* can be adjusted from normal to table surface to "in plane" with the table surface on some machines of this type. If the center of gravity of the test article is any appreciable distance from the table and the test article is large in mass, the resulting moments on the table due to motion in the plane of the table are frequently sufficient to cause serious table rocking. This rocking is a consequence of the practical limit on stiffness which can be built into the moving parts.



4. *Purity of table waveform* can be affected by looseness or free play in any of the moving parts which would cause impact loads. Impact loads equivalent in magnitude to the primary generated forces occur easily from small clearances. These impact loads produce acceleration disturbances directly and can excite higher frequency modes in all the structural elements, resulting in a complete masking of the fundamental generated acceleration waveform. Ball bearings in good condition can cause mechanical noise detectable in the table waveform. The waveform distortion due to bearing noise and free play is variable and depends upon the frequency of operation and the displacement adjustment.
5. *High force output* combined with relative simplicity and low cost are advantages of this type of vibration generator. Force level attained in this type of machine varies as required to maintain constant table displacement. If the table load is an ideal mass, the force generated is proportional to the square of the operating frequency. In some of the more expensive machines of this type, the crankpin offset may be adjusted while the machine is in operation; in this way, the displacement of the table motion is adjusted. Force ratings of this type of machine range from 25 to 8000 pounds of generated force. These machines, however, are usually rated by the maximum test-specimen weight that can be safely mounted on the table, rather than by the generated force.

mechanical resonances in the test object or its mounting will very likely occur in or near the operating frequency range. These resonances will cause appreciable variations in tab'e displacement independent of adjustments in the value of the rotating eccentric mass causing the vibratory force.

Electrodynamic exciters, Table 4, as the name suggests, generate their force by electromagnetic action. Table motion in this type of exciter is generated in the same way that a loudspeaker is driven. The table is attached to a current-carrying coil located in the air gap of a powerful magnet. Magnitude and direction of the current in the driver coil determine the magnitude and direction of the generated force

The generated force in the electrodynamic exciter is independent of frequency variations. There is no inherent relationship between values of table displacement, velocity, or acceleration as frequen-

Table 3—Characteristics of Eccentric-Mass Vibration Exciters

1. *Frequency range* is limited. Maximum operating frequencies of 60 cps are commonly available, while in some of the smaller machines of this class, operating frequencies of 120 cps are attainable.
2. *Table motion* normal to, or in the plane of, the mounting surface is possible. To generate motion in the plane of the table surface, the center of gravity of the table and mounted test article must be put in the plane of the generated force. This is necessary to insure translational motion without rotation or rocking motion. To adjust the center of gravity, a counterbalance must be added under the table where the rotating shaft is located. If the test article is not a rigid mass and resonances occur in or near the operating frequency range, no single adjustment of the counterbalance will insure translational motion without added rotational motion.
3. *Wave form* can be quite pure. Good design can minimize the effect of bearing clearances. Absence of reversed forces through bearings or sliding joints eliminates impact forces and their effect on table acceleration. Bearing noise from the shaft supporting the eccentric weight will affect table acceleration waveform, however.

The table of this type of vibration exciter is not constrained to a single direction of movement. It is freely suspended on soft springs and responds in the direction of generated force. Linear motion is obtained by proper rotation and phasing of two or more equal eccentric masses. Motions in directions other than that intended are precluded by virtue of zero forces in these directions. If the test article is not a rigid mass and has elastic or inertia coupling between the test direction of motion and other directions, the resulting forces (or moments) will cause unwanted motions to be superimposed on the desired motion.

4. *Wide force range* is possible, since the generated force is dependent upon the operating frequency and the amount of eccentric and mass on the rotating shaft. Maximum forces of 25,000 pounds are attainable in this type of vibration exciter.

Ingenious methods have been devised which allow the easy adjustment of force and frequency by controls external to the vibration exciting machine. These control methods allow constant acceleration or constant displacement to be maintained under conditions where the table, test article, and table attachment are rigid. If the table and mounted test article depart from rigid-mass state, the eccentric mass must be adjusted by manual or other means as the frequency is changed.

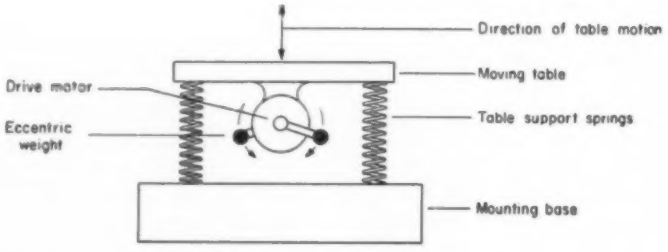
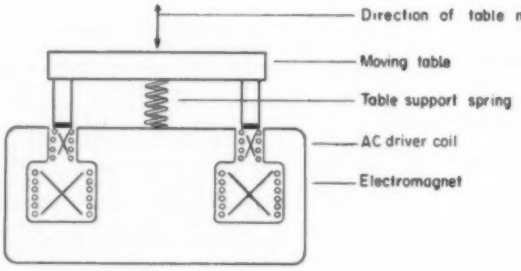


Table 4—Characteristics of Electrodynamic Vibration Exciters

1. *Frequency range* covered by various models of exciters of this type is 0.3 to 10,000 cps. Minimum frequency is determined by the low-frequency characteristics of the driving power supply. Maximum frequency is limited by the power supply or the frequency of major resonances in the moving-table assembly.
2. *Table motion* is limited to the plane normal to the table surface. Exciters of this type can be easily oriented to horizontal or vertical motion by rotating the complete exciter. If motion parallel to the plane of the mounting surface is desired, the vibration exciter must be connected to drive a separate table oriented with its mounting plane parallel to the direction of motion of the vibration exciter.
3. *Waveform* of exceptional purity is possible since the table motion of this type of vibrator results from electrically generated forces. Electrical voltages and currents from the variable-frequency power supply can be generated with small harmonic distortion and acceleration waveform similar to the force or current waveform results. Velocity and displacement waveforms are successively improved by the mechanical integration of the acceleration and velocity waveforms.
4. *Force output* of this type of exciter is directly proportional to current in the driver coil. Maximum force is limited by the current-carrying capacity of the electrical driving coil. Presently available exciters of this type are rated at 1 pound to 12,500 pounds generated force. Units of larger capacity are feasible and are being constructed.



cy is changed or the mass on the table is changed. The value of the generated force is easily controlled electrically and can be programmed or automatically controlled to give constant acceleration or displacement as frequency is changed, regardless of the load reaction on the table.

Relative motions between the exciter table and frame are across flexible support springs. Essentially standard units, therefore, can be placed in altitude chambers which employ wide ranges of temperature, pressure, and humidity. Since exciter controls are electrical, they can easily be remotely located. Absence of rotating and sliding parts reduces problems of wear and changes in performance with service.

Testing Problems

Though the proper test specification is written, and the correct vibration exciter chosen, there are additional problems to be solved during actual test performance. First to be considered is the seemingly simple matter of mounting brackets.

Mounting brackets are required to attach the test article to the vibration table. They are necessary because mounting points on the test article seldom coincide with mounting holes drilled in the table. Furthermore, the introduction of vibration along three perpendicular axes requires angle brackets if the mounting points are confined to a single plane.

An ideal bracket should have infinite rigidity, preferably without weight. It must be rigid in order to transmit forces without strain. Strain would cause unequal vibration levels at the test article attachment compared to the table level. Furthermore, unequal strains most probably would result at different mounting points and cause rotational motions and distortions in the test article in addition to the translational motions intended. The mounting bracket should be virtually weightless to keep it from absorbing the available generated forces from the vibration table.

Needless to say, available materials are not infinitely rigid; therefore, the bracket design must provide maximum rigidity with least weight in order to preclude resonance in the bracket, with or without mass considerations of the test article. If the test article is a complete gun turret weighing perhaps 200 pounds, with mounting points on four sides, each spaced from the other by dimensions of 18 inches or more, it becomes practically impossible to devise a bracket which is stiff up to 500 cps. Yet to fulfill the test requirement, such a bracket is required.

Table motion can vary if a wide range of test frequencies is required on a test article which does not act as a rigid mass throughout the frequency range and cause further test complications. Consider a test article made up of a vertical column and a large weight supported by a horizontal member extending from the column. The center of gravity of such a test article can be located on the center of the vibration table so that the generated forces are directed through the center of gravity of the test subject. The resulting motion at low frequencies is purely translational because of the absence of moments transferred to the table.

As the frequency of vibration is increased, a critical point will be reached where the mass supported on the horizontal member will resonate, generating torque or moments which are transmitted to the table. These moments will cause a rocking motion of the table to be superimposed on the generated motion normal to the plane of the table. Operating above this critical frequency will isolate the vibration of the column from the mass, resulting in an apparent shift in position of the center of gravity of the test article. A rocking moment will be introduced into the table, at all frequencies above the critical, dependent upon the resulting effective mass and center-of-gravity location. Rocking motion of the table detracts from the quantitative results of the tests since the test specification usually states or implies pure translational motion.

Large electromagnetic vibration exciters, operable to 500 cps and higher, have been successfully designed to eliminate resonant modes involving motions in the direction of the generated force. All secondary resonances of the moving table have not been eliminated, including resonances in the table supporting constraints and lateral or rocking modes in the moving table assembly. Consequently, at discrete frequencies, should the test article provide substantial forces or moments which can cause the excitation of these secondary modes, considerable departure from pure translational motion in the table may result.

These problems can be effectively controlled by ingeniously constructed test brackets or other setups used to transmit the vibration to the test article. Briefly, three basic approaches are commonly utilized: (1) a central force takeoff from the vibration table; (2) mass adjustments for shifting the frequency of unwanted natural mode resonances; or (3) the use of several test fixtures for different frequency ranges.

Waveform distortion from the test article itself is present under certain circumstances. With vibration exciters which derive their motion from the generation of a force, a sinusoidal force will produce sinusoidal table motion only when the motional impedance of the test article can be represented by ideal springs, masses, and viscous damping. The existence of free play in the test article or the generation of forces within the test article not proportional to displacement, velocity or acceleration produced by the test article will cause distortion in the waveform of the vibration exciter.

Effect of free play is to produce hammer-like

blows, rich in harmonics, which are particularly effective in exciting all the natural modes of the vibration exciter and test article at and above the test frequency. These effects are particularly noticeable in the acceleration waveform and can be minimized only by having the size and weight of the vibration table large compared to that of the test article.

Another source of waveform error is the presence of a test article resonance having very little damping and capable of generating relatively large forces. Very slight distortions in the generated force driving the table can excite such a resonance when one of its harmonics coincides in frequency with the resonant frequency. Distortion appears at discrete frequencies corresponding to one-half, one-third, one-fourth, one-fifth, etc., of the resonant frequency. Resonance is excited by the second, third, fourth, fifth, etc., harmonic, respectively, of the fundamental frequency of the generated force. If the several harmonics in the generated force are held to 1 per cent of the fundamental, a resonant buildup of 100 to 1, which is not uncommon, would produce an acceleration waveform distortion of 100 per cent. This can occur whether the resonance is in the operating frequency range or not. The test procedure requires testing with simple-harmonic motion. Vibration exciters having individual harmonics of the order of 1 per cent represent good quality units.

Altitude chambers are needed if the test requires vibration in the presence of variable temperature, pressure, and humidity. Under such circumstances, all testing must be carried on by remote indications. Obviously, with the problems previously mentioned, this added restriction makes the quantitative interpretation of vibration test results even more diffcult.

Another problem arises if the chamber is not large enough to enclose the vibration exciter. In this case, the exciter must be placed outside the chamber. The problem of driving a table in the chamber from a drive rod of sufficient length to pass through the chamber wall and connect to the external vibration exciter involves problems of stiffness and mass which severely limit the range of operable frequencies.

Summary

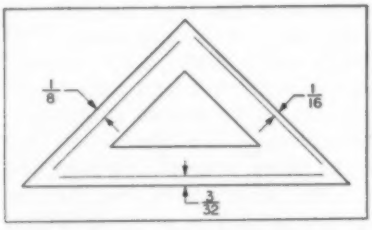
Vibration testing at frequencies above 30 to 50 cps may include serious problems in obtaining pure translational motion of known level. In general, the problem increases in difficulty with larger, more complex test articles and as the test frequency increases. All types of currently available test equipment fall short of the performance described as ideal. Even so, vibration testing has resulted in improved reliability of a wide variety of products.

Many elements of faulty design are revealed by simple vibration tests independent of the quantitative accuracy of the vibration level. Precise agreement of results obtained on different vibration exciters, and an accurate evaluation of the margin of safety attained by meeting the test requirements, cannot be expected until greater quantitative accuracy in vibration testing is obtained.

Tips and Techniques

Drawing Equally Spaced Parallels

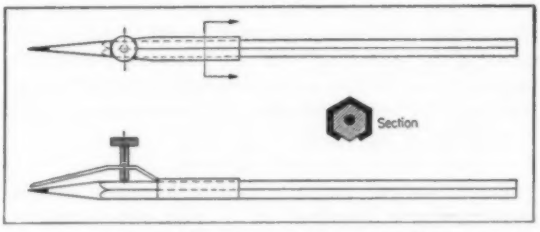
LINES scribed on a transparent triangle, as shown, can be used to draw accurate parallels. The scribed line is placed over the line already drawn. Scribed lines can be placed at any distance from the edge of the triangle, but use of different spacings makes the tool more flexible for different



cross-section spacings, etc. If desired, the lines can be filled with colored wax-pencil lead to contrast with the drawing.—T. BULLOCH, *Designers for Industry Inc., Cleveland.*

Line Spacer

A line spacer for cross sectioning, and for making parallel lines for tables or lettering, can be hand-formed from light-gage brass, copper, tin or aluminum. Spacing between lines is adjusted with the thumbscrew; it can be from 1/32 to ¼-in. or larger depending on design of the gadget.—N. E. BROWN, *Wellsville, O.*



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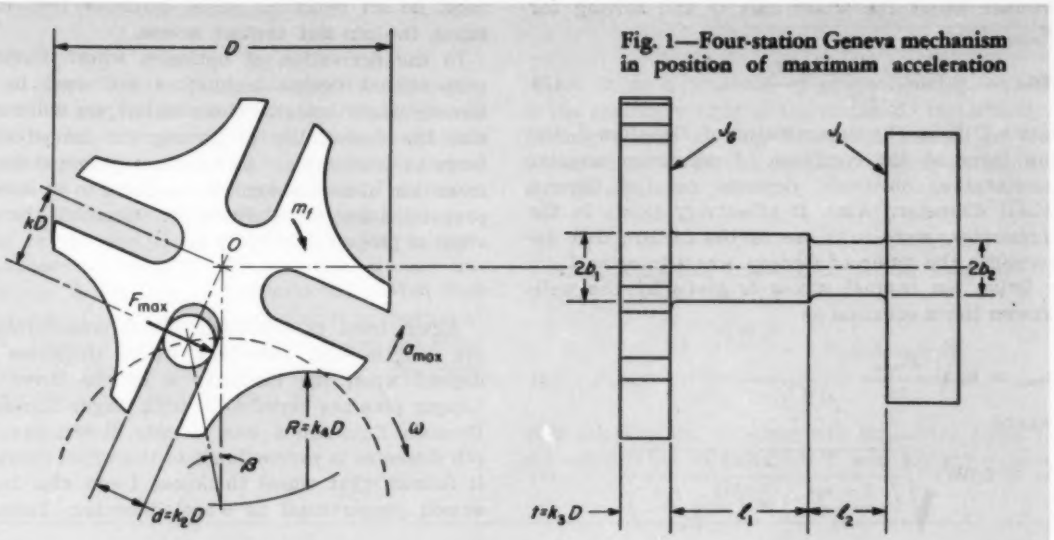


Fig. 1—Four-station Geneva mechanism in position of maximum acceleration

How to design

Geneva Mechanisms

to minimize contact stress and torsional vibration

By Ray C. Johnson, *Senior Design Engineer*
Eastman Kodak Co., Rochester, N. Y.

INCREASED demands for high-speed Geneva wheel operation have focused attention on two undesirable characteristics inherent in this mechanism. These characteristics, found to some degree in many intermittent-motion mechanisms, are (1) high contact stress between the drive pin and the wheel slot and (2) vibratory motion of the driven inertia load. Both of these factors adversely affect performance and life.

Chief effect of high contact stress is to cause excessive drive-pin wear, with premature failure of the Geneva drive. On the other hand, vibratory motion often interferes with the operation of the mechanism or causes excessive wear on Geneva parts, such as the locking device.

This article outlines a simple method for minimizing drive-pin contact stress, and gives a procedure for reducing undesirable vibratory motion.

Minimizing Contact Stress

A four-station Geneva mechanism which intermittently rotates an inertia load J_L against a frictional retarding moment M_f is shown in *Fig.* 1. Lichtwitz has analyzed the motion of Geneva mechanisms and shows that, for a given number of stations, the angular motion of the Geneva wheel is a function of the angular position and velocity of the drive-pin shaft.* Angular motion of the Geneva wheel is also shown to be independent of its diameter D. The mechanism in *Fig.* 1 is shown in its position of maximum wheel acceleration, and the following discussion is concerned with the forces and stresses obtained in this instantaneous position.

Since both the distance from the drive-pin axis to the drive-shaft axis and the distance from the drive-shaft axis to the Geneva-wheel axis are directly proportional to the wheel diameter D, the torque arm of the pin contact force with respect to the wheel axis is also directly proportional to the diameter. This torque arm is denoted by kD in *Fig.* 1, where k is a constant of proportionality. Because wheel acceleration is maximum in the position shown, the drive pin exerts a torque $F_{max}\ kD$ on the Geneva wheel. Summing

*Otto Lichtwitz—"Mechanisms for Intermittent Motion," MACHINE DESIGN, Dec. 1951, Pages 134-148.

torques about the wheel axis O and solving for F_{max},

$$F_{max} = \frac{(J_G + J_L)\, a_{max} + M_f}{kD} \quad \ldots\ldots (1)$$

Since D is in the denominator of Equation 1, the pin force at the condition of maximum angular accelaration obviously depends on the Geneva wheel diameter. Also, D effectively exists in the numerator, since it is one of the factors that determines the value of Geneva wheel intertia J_G.

Drive pin contact stress is given by the well-known Hertz equation as

$$s_{max} = k_1 \sqrt{\frac{F_{max}}{td}} \quad \ldots\ldots (2)$$

where

$$k_1 = 0.798 \sqrt{\frac{1}{\left(\frac{1-\nu_1^2}{E_1}\right) + \left(\frac{1-\nu_2^2}{E_2}\right)}} \quad \ldots (3)$$

A study of Equation 2 shows that minimum contact stress is obtained when both the driving pin diameter d and the Geneva wheel thickness t are as large as practical. However, the Geneva wheel diameter D cannot be specified with certainty at this point. Equation 1, for example, shows that small wheel diameters cause high pin forces because D is in the denominator. Furthermore, large wheel diameters, because of high wheel inertia J_G, also cause high pin forces. Obviously there must be an optimum wheel diameter that minimizes the pin-slot contact stress.

In the derivation of optimum wheel diameter, proportional design techniques are used in the Geneva wheel layout. These techniques will recognize the desirability of having pin diameters as large as practicable. As for other principal dimensions, pin diameter d can be assumed to be directly proportional to wheel diameter. Denoting the constant of proportionality by k_2,

$$d = k_2 D \quad \ldots\ldots (4)$$

Again from proportional design considerations, pin length—and therefore wheel thickness t—depend upon the diameter d of the drive pin. Longer pins are permissible with larger diameters. Because Equation 4 has already shown that the pin diameter is proportional to the wheel diameter, it follows that wheel thickness t can also be assumed proportional to wheel diameter. Denoting

Table 1—Geneva Design Constants

—Basic Geneva Properties—				—Suggested Design Constants—				
n	β	a_{max}/ω^2	a_v/ω^2	k	k_2	k_3	k_4	k_5
3	4° 46′	31.44	1.732	0.1546	0.16	0.16	0.70	0.00353
4	11° 24′	5.409	1.000	0.2384	0.15	0.15	0.35	0.00506
5	17° 34′	2.229	0.7265	0.2930	0.14	0.14	0.24	0.00516
6	22° 54′	1.350	0.5774	0.3311	0.14	0.14	0.17	0.00588
7	27° 33′	0.9284	0.4816	0.3592	0.14	0.14	0.13	0.00573
8	31° 38′	0.6998	0.4142	0.3807	0.13	0.13	0.10	0.00575
9	35° 16′	0.5591	0.3640	0.3977	0.12	0.12	0.08	0.00584
10	38° 30′	0.4648	0.3249	0.4112	0.10	0.10	0.08	0.00540

Nomenclature

a_{max} = Maximum angular acceleration of Geneva wheel, rad per sec²
a_v = Angular acceleration of Geneva wheel at instant when drive pin leaves the wheel slot, rad per sec²
b = Radius of Geneva wheel shaft, in.
c = Torsional stiffness of Geneva wheel shaft, lb-in. per rad
D = Diameter of Geneva wheel, in.
d = Diameter of Geneva drive pin, in.
E_1 = Modulus of elasticity of Geneva drive pin material, psi
E_2 = Modulus of elasticity of Geneva wheel slot material, psi
E_s = Shearing modulus of elasticity of Geneva wheel shaft material, psi
f_n = Natural frequency of free torsional vibrations for load inertia, cps
F_{max} = Force between the Geneva drive pin and wheel slot at instant when the angular acceleration of Geneva wheel is a maximum, lb
g = Acceleration due to gravity, 386 in. per sec²
J_G = Mass moment of inertia of Geneva wheel about axis of rotation, lb-sec²-in.
J_L = Mass moment of inertia of load about axis of rotation, lb-sec²-in.
J_s = Polar moment of inertia of cross sectional area of Geneva wheel shaft, in.⁴
k = Ratio of distance between Geneva center and drive pin to Geneva wheel diameter
k_1 to k_5 = Constants
l = Length of Geneva wheel shaft, in.
M_f = Retarding moment acting on Geneva wheel, lb-in.
n = Number of slots in Geneva wheel
R = Locking radius on Geneva wheel, in.
s_{max} = Contact compressive stress between Geneva drive pin and wheel slot at maximum angular acceleration of Geneva wheel, psi
T = Torque, lb-in.
t = Thickness of Geneva wheel, in.
W = Energy available for free torsional vibrations when Geneva drive pin leaves wheel slot, in.-lb
w = Specific weight of Geneva wheel material, lb per cu in.
β = Angle shown in *Fig.* 1 for Geneva mechanism in position of maximum angular acceleration, deg.
ν_1 = Poisson's ratio for Geneva drive pin material
ν_2 = Poisson's ratio for Geneva wheel slot material
ω = Angular velocity of Geneva drive shaft, rad per sec
θ = Elastic rotational deformation of Geneva wheel shaft when drive pin leaves wheel slot, rad

this constant of proportionality by k_3,

$$t = k_3 D \quad \ldots\ldots (5)$$

The proportional design assumption also provides a means for relating the Geneva inertia J_G to the wheel diameter D. From basic mechanics, the mass moment of inertia of the Geneva wheel is equal to its mass times its radius of gyration squared. The mass of the wheel is directly proportional to its specific weight and to its volume. Furthermore, under the proportional design assumption, the volume is proportional to D^3, and the square of the radius of gyration is proportional to D^2. Hence, from this line of reasoning the mass moment of inertia of a proportionally designed Geneva wheel can be expressed as

$$J_G = \frac{k_5 w D^5}{g} \quad \ldots\ldots (6)$$

where k_5 is a constant of proportionality and w is the specific weight of the material. Incidentally, locking radius R, *Fig.* 1, is also related to the wheel diameter by the constant of proportionality k_4. Therefore

$$R = k_4 D \quad \ldots\ldots (7)$$

When Equation 6 is substituted in Equation 1,

$$F_{max} = \frac{\left(\frac{k_5 w D^5}{g} + J_L\right) a_{max} + M_f}{k D}$$

This relationship, together with Equations 4 and 5, are substituted in Equation 2, and the expression

Example 1 – Design for Minimum Stress

A four-station Geneva mechanism intermittently rotates a solid steel 4-in. diameter cylinder, ¼-in. thick. A constant frictional moment of 2 lb-in. opposes rotation of the cylinder and drive-shaft speed is 600 rpm.

First steps are to calculate the load inertia and the Geneva wheel acceleration. The moment of inertia of the load is

$$J_L = M_L \frac{R_L^2}{2} = \frac{\pi R_L^2 w}{4g}\left(\frac{R_L^2}{2}\right)$$

$$= \frac{\pi (2)^2 (0.283) (2)^2}{4 (386) (2)}$$

$$= 0.0046 \text{ lb-sec}^2\text{-in.}$$

where M_L and R_L are the mass and radius of the load, respectively. From *Table* 1, maximum acceleration of the Geneva wheel is

$$a_{max} = 5.409\,\omega^2 = 5.409\left[\frac{600\,(2\pi)}{60}\right]^2$$

$$= 21{,}300 \text{ rad per sec}^2$$

Contact stresses will now be determined for the optimum Geneva wheel and for wheels smaller and larger than optimum. In each case, the design proportions of *Table* 1 are used.

Optimum Wheel: From Equation 9, the mass moment of inertia of the optimum Geneva wheel is

$$J_G = \frac{3}{2}\left[0.0046 + \frac{2}{21{,}300}\right]$$

$$= 0.00704 \text{ lb-sec}^2\text{-in.}$$

For a four-station Geneva wheel with the value of k_5 from *Table* 1, Equation 6 gives

$$J_G = 0.00506\, D^5\left(\frac{0.283}{386}\right) = 0.00704$$

Therefore, $D = 4.53$ in.

The value of D and the constants from *Table* 1 are entered in Equations 4, 5, and 7. Results are $t = 0.15(4.53) = 0.68$-in., $d = 0.15(4.53) = 0.68$-in., and $R = 0.35(4.53) = 1.59$ in. Force torque arm $kD = 0.2384(4.53) = 1.08$ in.

From Equation 1,

$$F_{max} = \frac{(0.00704 + 0.0046)\,(21{,}300) + 2}{1.08}$$

$$= 232 \text{ lb}$$

For the steel drive pin and Geneva wheel, $E = 30{,}000{,}000$ psi and $\nu = 0.3$. Equation 3 therefore gives $k_1 = 3240$.

Finally from Equation 2, contact stress for the optimum Geneva design is

$$s_{max} = 3240\sqrt{\frac{232}{(0.68)\,(0.68)}}$$

$$= 72{,}600 \text{ psi}$$

Wheel Too Small: Here, the Geneva wheel diameter is arbitrarily set at 2 in. Then: $D = 2.00$ in., $d = 0.30$-in., and $t = 0.30$-in. Inertia J_G is again calculated from Equation 6, using k_5 from *Table* 1. In this case, $J_G = 0.000119$ lb-sec^2-in. From Equation 1 as before, $F_{max} = 215$ lb. From Equation 2 contact stress is $s_{max} = 158{,}200$ psi for the design where the Geneva wheel is too small. This contact stress is 218 per cent of the stress of 72,600 psi calculated for the optimum wheel.

This case shows the possible hazard of letting a desire for minimum inertia influence design of high-speed mechanisms.

Wheel Too Large: Assume that the Geneva wheel diameter is arbitrarily set at 6 in. When carried through as before, the analysis gives $F_{max} = 499$ lb, and $s_{max} = 80{,}400$ psi. This contact stress is 111 per cent of the optimum stress at 72,600 psi. Moreover, the pin force is decidedly larger than the optimum F_{max}, which in itself is a disadvantage.

for maximum contact stress becomes

$$s_{max} = \frac{k_1}{\sqrt{k\,k_2\,k_3}} \sqrt{\frac{\left(\frac{k_5\,w\,D^5}{g} + J_L\right) a_{max} + M_f}{D^3}} \quad (8)$$

To minimize the contact stress, a partial derivative of s_{max} with respect to D is taken in Equation 8 and equated to zero. This derivative expression, after simplification by use of Equation 6, can be rearranged to give

$$J_G = \frac{3}{2}\left(J_L + \frac{M_f}{a_{max}}\right) \quad (9)$$

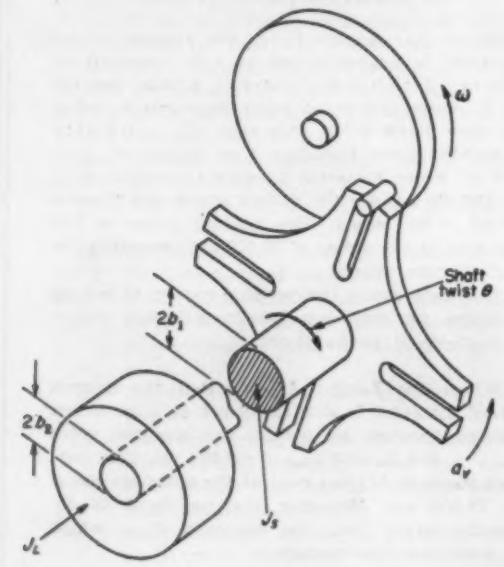
Equation 9 is the crux of the analysis to this point. It shows that minimum pin contact stress is obtained when the mass moment of inertia of the Geneva wheel has a particular value that depends on (1) inertia of the load, (2) frictional forces and (3) speed of operation. For most practical problems, the term M_f/a_{max} in Equation 9 will be negligible with respect to J_L and can be ignored.

Accurate layouts were made by the author for Geneva wheels that have three to ten stations, using a set of proportions that seemed to conform well with good practice. The proportionality constants for these designs are given in *Table* 1.

Use of these suggested constants will simplify the design procedure. The calculated value for J_G from Equation 9 can be placed in Equation 6 and the desired wheel diameter D found at once by extracting k_5 from *Table* 1. However, a designer can choose different proportions, if he wishes and then work out the design by use of Equation 9.

How these foregoing ideas may be applied in actual design is demonstrated by *Example* 1.

Fig. 2—Geneva mechanism at instant drive pin is leaving slot



Minimizing Vibration

Lichtwitz has shown in his analysis that the Geneva wheel is decelerating at the instant the drive pin leaves the wheel slot. Deceleration a_t is given in *Table* 1. Because the Geneva wheel shaft, (*Fig.* 2), is decelerating the inertia load J_L, it transmits a torque at the instant the drive pin leaves the wheel slot. The magnitude of this shaft torque, neglecting frictional forces, is given by

$$T = J_L\,a_t \quad (10)$$

When a shaft of length l transmits a reasonable torque, it undergoes elastic rotational deformation, and the angle of deformation is

$$\theta = \frac{T\,l}{J_s\,E_s}$$

Therefore, from Equation 10, the elastic rotational deformation at the instant the pin leaves the slot is

$$\theta = \frac{J_L\,a_t\,l}{J_s\,E_s} \quad (11)$$

Polar moment of inertia J_s is

$$J_s = \frac{\pi b^4}{2} \quad (12)$$

where b is the shaft radius.

The shaft twist θ (*Fig.* 2) at the beginning of the rest period represents stored potential energy which is capable of initiating torsional vibrations of the inertia load. These vibrations persist during the rest period of the Geneva wheel and have an initial amplitude given by Equation 11.

For many applications, vibrations of even small magnitude cannot be tolerated. Large vibrations, on the other hand, often cause exorbitant wear on parts such as the Geneva locking device. Equations 10, 11 and 12 reveal a means for reducing the amplitude of such free torsional vibrations.

For example, from Equation 10, it is obvious that shaft torque can be reduced by decreasing the inertia of the load. Decreasing the load inertia J_L is also desirable from a pin-stress standpoint.

From Equation 11, the length of the Geneva wheel shaft l should also be as small as possible, and the shaft should be a stiff material with large shearing modulus E_s.

Finally, from Equation 12, the polar moment of inertia of the shaft J_s should be as large as practical, implying the use of a large-diameter shaft.

For a shaft made of a single material, but consisting of various diameter cross sections, the torsional deflection equation corresponding to

Equation 11 is

$$\theta = \frac{J_L a_v}{E_s}\left(\frac{2}{\pi}\right)\left(\frac{l_1}{b_1^4}+\frac{l_2}{b_2^4}+\frac{l_3}{b_3^4}+\ldots\right) \quad (13)$$

Considering that the Geneva wheel is clamped during the rest period, the natural frequency for free torsional vibrations of the load inertia J_L is

$$f_n = \frac{1}{2\pi}\sqrt{\frac{c}{J_L}} \quad (14)$$

The torsional stiffness c of the shaft is found from Equation 13:

$$c = \frac{T}{\theta} = \frac{\left(\frac{\pi}{2}\right)E_s}{\left(\frac{l_1}{b_1^4}+\frac{l_2}{b_2^4}+\frac{l_3}{b_3^4}+\ldots\right)} \quad (15)$$

From basic mechanics, the energy of free torsional vibrations is

$$W = \frac{c\theta^2}{2} \quad (16)$$

Equations 11 through 16 enable a designer to calculate the amplitude, frequency and energy of the load vibrations and demonstrate that, through careful selection of components, the magnitude of vibrational motion can be held to an acceptable value.

Application of these analytical methods is demonstrated in *Example* 2.

Summary of Geneva Design

For a Geneva mechanism having a given number of stations, the following design steps are recommended:

1. Using Equations 10 through 16, select a Geneva wheel shaft that will give satisfactory vibratory characteristics. Equation 13 is the most important equation in this group and should be used at the start of the analysis for choosing an acceptable shaft size.

2. Calculate the mass moment of inertia of the Geneva wheel shaft and, if appreciable, include it with the load inertia, J_L.

3. Use Equation 9 to calculate the optimum moment of inertia for the Geneval wheel, J_G.

4. Using *Table* 1 and Equation 6, calculate the optimum diameter D of the Geneva wheel. Determine the optimum Geneva wheel physical dimensions by using Equations 4, 5 and 7.

5. The pin stress at the condition of maximum angular acceleration may then be calculated by Equation 8.

Example 2 – Design for Acceptable Vibration

Design data and calculated values from *Example* 1 are used in this example. Also, a constant-diameter shaft connects the Geneva wheel with the load. A shaft design that gives exorbitant vibratory motion will be considered first.

Exorbitant Vibratory Motion: Here, the Geneva-wheel shaft diameter $2b$ is chosen as ⅜-in. Such a small diameter might be selected with the idea of keeping inertias low. The shaft is steel and is 5 in. long.

From Equation 10, shaft torque is

$$J_L a_v = 0.0046\ [1.000]\left[\frac{600\ (2\pi)}{60}\right]^2$$
$$= 18.15\ \text{lb-in.}$$

From Equation 12,

$$J_s = \frac{\pi b^4}{2} = \frac{\pi}{2}\left(\frac{3}{16}\right)^4$$
$$= 0.00194\text{-in.}^4$$

Hence, from Equation 11,

$$\theta = \frac{18.15\ (5)}{0.00194\ (12{,}000{,}000)}$$
$$= 0.00390\text{-rad}$$

Therefore, at the periphery of the 4-in. diameter load cylinder, the amplitude of free vibrations will be $2\theta = 2(0.0039) = 0.0078$-in., or 0.0156-in. total vibratory motion. This vibrational motion is exorbitant.

Acceptable Vibratory Motion: Assume that the wheel shaft diameter $2b$ is increased to 1 in. and that the shaft length l is reduced to 3 in. Then, from Equation 12, $J_s = 0.0982\text{-inch}^4$. Because the initial shaft torque is still 18.15 lb-in., Equation 11 gives

$$\theta = \frac{18.15\ (3)}{0.0982\ (12{,}000{,}000)}$$
$$= 0.0000462\text{-rad}$$

Therefore, at the periphery of the load cylinder the amplitude of free vibrations has been reduced to $2(\theta) = 2(0.0000462) \approx 0.0001$-in., and the total vibratory motion is now less than 0.0002-in.

Reduction of vibration, by a factor of 85 to 1, has been achieved with comparatively little increase in inertia.

The mass moment of inertia of the 1-in. by 3 in. shaft is only 0.000216 lb-sec²-in., which is less than 5 per cent of the load inertia of 0.0046 lb-sec²-in.

A comparison of the vibratory characteristics is given below for the two designs. Frequencies and energies shown were obtained directly from Equations 14, 15 and 16.

Shaft Diam. (in.)	Shaft Length (in.)	Double Amplitude (in.)	Frequency (cps)	Vibration Energy (in.-lb)
⅜	5	0.0156	159	0.0354
1	3	0.0002	1470	0.00042

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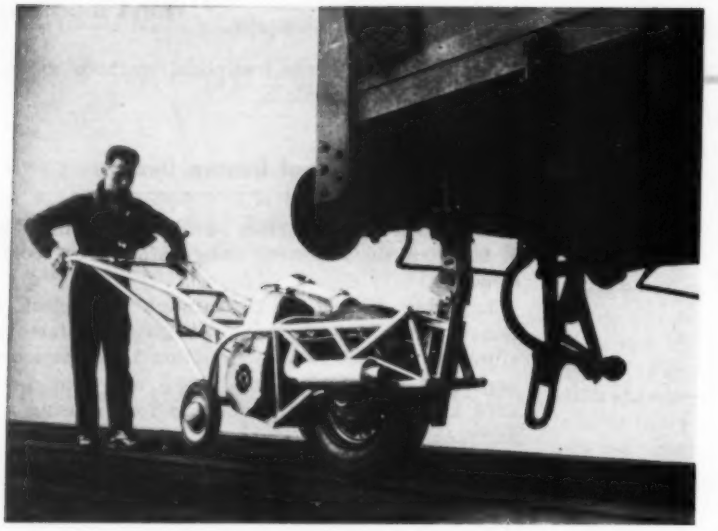
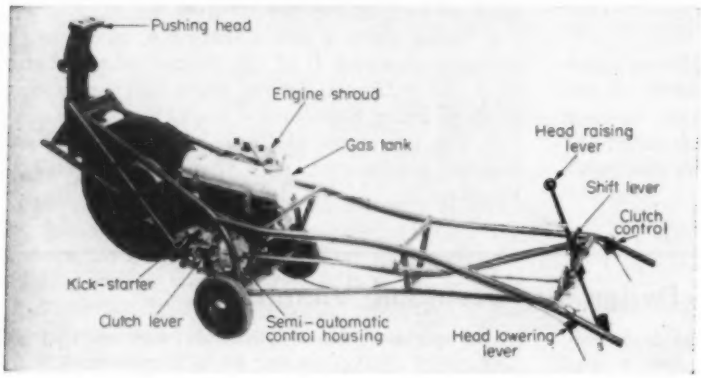
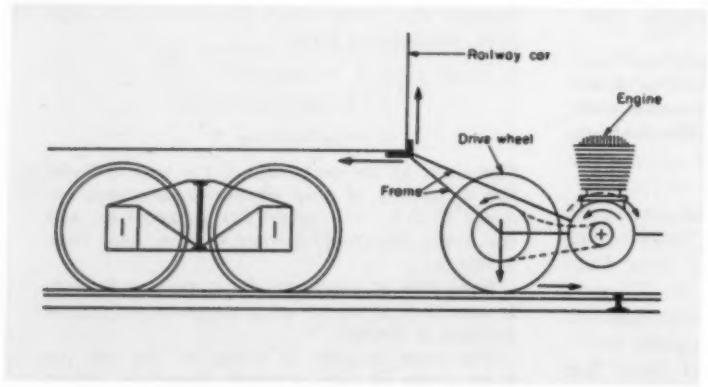






WEIGHT of a railway car itself is used to increase traction of a wheel driven by a 12-hp gasoline engine to the point where a machine weighing less than 500 pounds can move a section of cars weighing more than 150 tons. Other features of the machine are a welded frame of high-strength steel tubing, clutch, four-speed transmission, planetary gear speed reducer and the necessary controls. Called the Locopulseur, the machine is a product of S. A. Ateliers de Construction de Jambes-Namur, Belgium. Total weight of the Locopulseur is 445 pounds. Length is 9 feet, 1 inch; height is 3 feet and width is 2 feet, 9 inches.

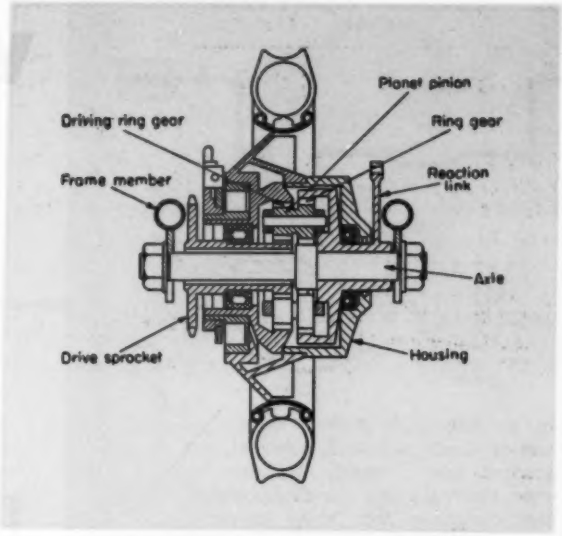
Two outrigger wheels, smaller than the main drive wheel, stabilize the machine when it is being moved from place to place. The tire on the main drive wheel is specially ribbed and has a concave surface for better adherence to the rail. The machine may also be used on the ground surface to separate one or more cars from a string. Over-all gear reductions of 192, 106, 60 and 46 to 1 result in travel speeds of 0.94 to 3.75 mph.

Information for this item was supplied by Jean Aterianus, sales engineer, S. A. Ateliers de Construction de Jambes-Namur.

Planetary gear speed reducer is mounted in the drive wheel and has a reduction ratio of 26.7:1. Reducer drive is through a sprocket to the input sun gear. Three double planet pinions drive two ring gears. One ring gear is connected to and drives the wheel through an overrunning clutch which allows the

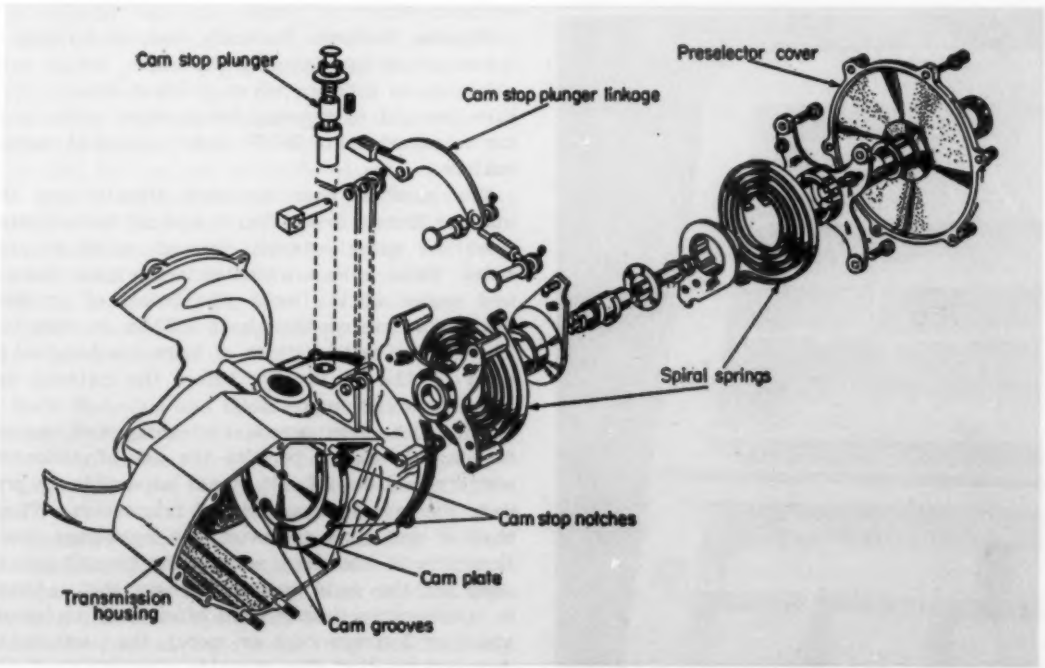
Small Engine Moves Railroad Cars

operator to move the machine forward at a rate faster than drive speed or to move backward when the reducer is not driven. The other ring gear is anchored to the frame by a reaction link and transmits torque to the frame. It is this torque which attempts to rotate the frame of the machine in such a manner as to provide upward thrust against the bottom of the freight car to be moved.



Semiautomatic gearshifting of the four-speed transmission is accomplished by a cam plate which moves the shift yokes and a pair of spiral springs which drive the cam plate. One spring is for upshifting; that is from first to second, second to third, etc. The other is for downshifting.

When the operator moves the gear selector lever, one or the other of the spiral springs is wound, but gears are not shifted since a pin, or cam-stop plunger, engages one of the cam-stop notches to prevent rotation of the cam. Gear shifting to the selected speed occurs automatically when the clutch is released. A linkage between the clutch operating lever and the cam-stop plunger releases the plunger when the clutch is operated, permitting the cam plate to rotate and move the shift yoke or yokes to the position corresponding to the selected gear



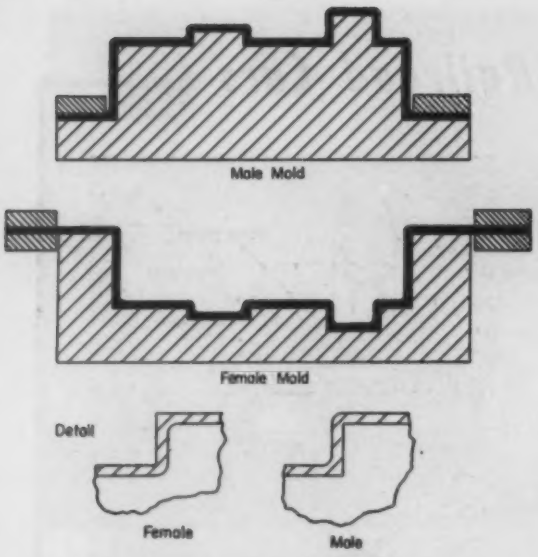
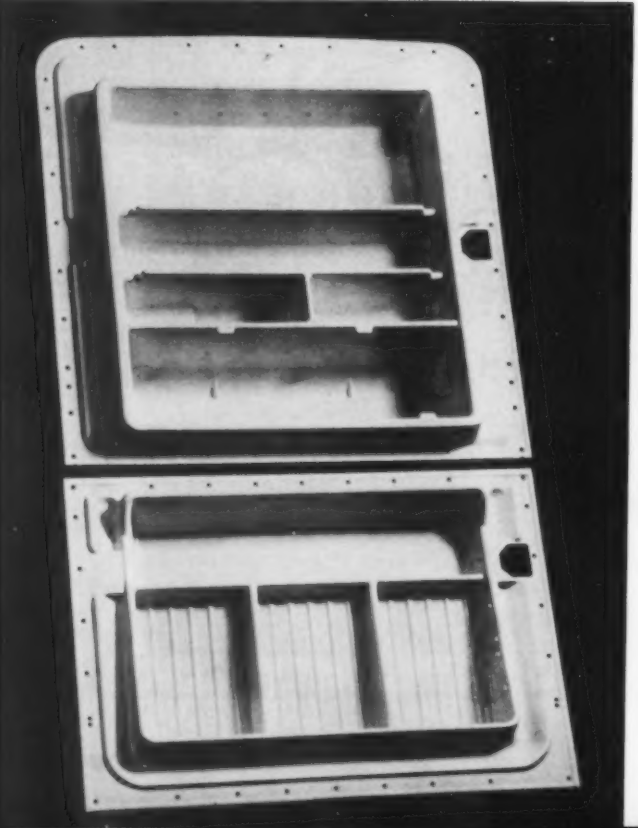


Fig. 1—Above—In vacuum forming, a sheet of plastic is heated, clamped, and stretched over a mold. Vacuum between the mold and the thermoplastic sheet completes the "deep drawing" process. Type of mold (male or female) determines location of sharpest detail (inside or outside, respectively)

Fig. 2—Below—Upper and lower door pans for a Deepfreeze home freezer and refrigerator combination illustrate depth of draw, size of sheet and complexity of contours possible by vacuum forming



Techniques for designing

Vacuum-Formed

IN PRINCIPLE, vacuum forming is the simplest and easiest of the several methods of shaping thermoplastic materials. In forming a modern, complex part, however, considerable skill and advanced techniques are required.

The rapid expansion of vacuum forming as a production technique for making cabinets, housings and components has been brought about by two principal factors. First, the process, which uses low-cost molds and equipment, is inherently economical. Second, low-cost materials with excellent physical characteristics can be used.

Forming Method: Basically, vacuum forming is accomplished by clamping the sheet, cut to suitable size, in a frame which holds it firmly. It is then brought to forming temperature (usually in the neighborhood of 300 F) under a bank of radiant heaters.

The sheet is then stretched tightly over the male or female mold, *Fig.* 1, and air is exhausted from the space between, through small vacuum holes. These holes are located in the lower corners and angles of the mold—the points of greatest draw—and are usually about 1/32-in. in diameter. The number and locations of holes are designed to draw off the air rapidly, before the material has a chance to cool appreciably.

One of the very practical advantages of vacuum forming is that it permits the use of undercuts which would be difficult, if not impossible, to produce by any other method of fabrication. Where shallow undercuts are used with light-gage sheet, flexibility of the sheet permits the formed part to snap off the mold readily. Where the undercut is considerably deeper (and often such undercuts are 2 or 3 inches deep or more), the part can be designed so that the movable plug which forms the undercut can be withdrawn after the sheet is lifted from the mold.

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Plastic Parts

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Extremely complex and difficult undercuts can be formed by the use of an insert which remains in the part permanently. Such inserts are often a valuable means of supplying extra strength at point of assembly.

Plastic Materials: Nearly all thermoplastic sheet materials to ⅛-in. thickness are formed quite easily. Heating time is proportional to the thickness. Such materials as acrylics and modified styrene are being commercially formed in thicknesses up to ¼-in.

A typical example might be rubber-modified styrene sheet. Such sheet is low in cost per square foot. Yet it possesses good impact strength, stability, and resistance to moisture and many chemicals. It is nontoxic, and available in a range of colors, although not in transparent form.

Several finishes are available—a soft matte finish, a polished surface, and a high-gloss surface having a brilliant, porcelain-like luster. This high-gloss sheet has been widely adopted by refrigerator manufacturers for parts such as door liners (*Fig.* 2), breaker strips, etc. It is also being used in many other kinds of equipment for the kitchen, home laundry, and so on, *Fig.* 3.

Mold Materials and Costs: One of the great advantages of vacuum forming is the use of relatively low-cost molds which can be made in a matter of days. Since the forming medium is vacuum, the molds never have to withstand pressures higher than atmospheric. Thus, wood molds can be used for sampling pilot runs and even for limited production. Excellent results have been obtained from molds of cast resin, aluminum or steel.

Another cost saving results from the fact only one mold, either male or female, is used for each part produced. Generally, male molds are less expensive since they can be built up instead of being

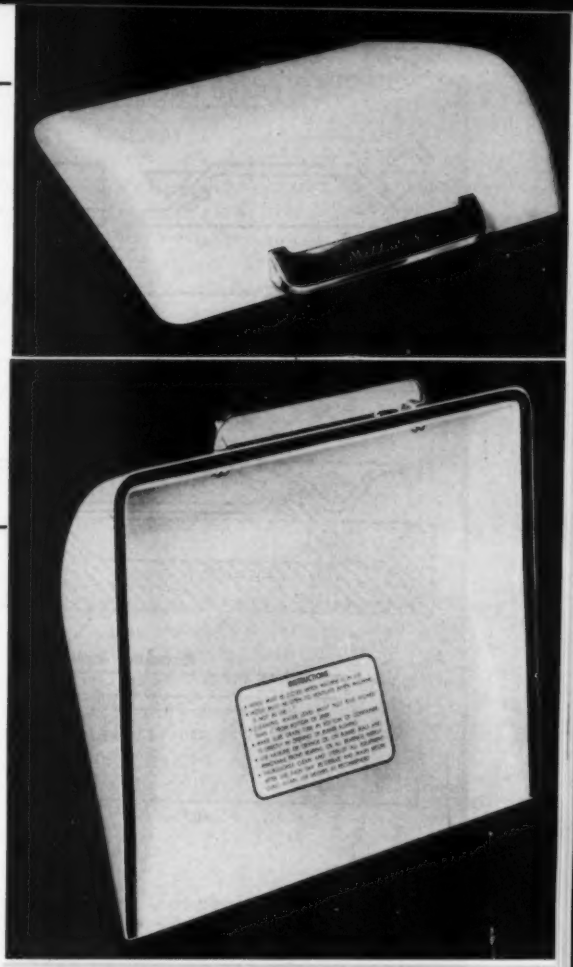
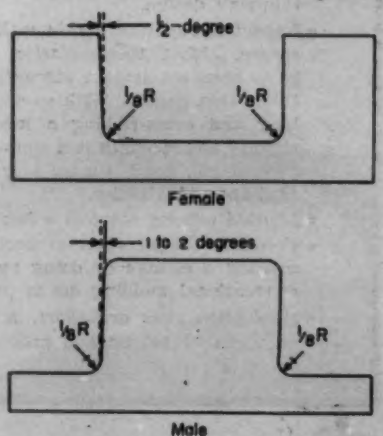


Fig. 3—Above—Tolerances on this two-piece vacuum-formed cover are said to compare favorably with those obtainable by closed-die plastic molding, even though tooling for vacuum forming is inexpensive. Made of Campco rubber-modified styrene sheet, the cover is manufactured for an automatic milkshake machine by Mills Industries Inc. The two lightweight halves are joined after forming, with a layer of glass-fiber insulation between

Fig. 4—Below—Minimum radii and draft, shown for male and female molds, should be liberalized if possible



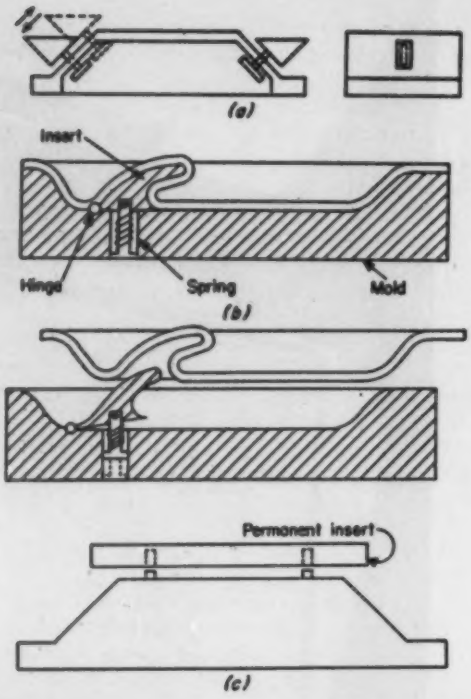


Fig. 5—Deep undercuts in the plastic part can be produced by three methods: *a*, a sliding insert in the mold, which moves to release the part; *b*, a hinged insert to form the undercut; or *c*, a permanent insert, locked into the component during forming. The permanent insert becomes a part of the finished piece

carved out of the mold material. However, a female mold can be quickly and inexpensively cast in a plastic resin or metal from a male pattern.

All this means that the speed and flexibility of production are high. Experimental changes can be made quickly at minimum cost. The switch from pilot run to full production can often be made in a matter of hours—at most two or three days.

Molds for vacuum forming should be well built. Cheaper wood molds may be easily cracked, and the metal form may be sprung by the vacuum if it it is too light. Seal between the mold and the sheet must be airtight; this can be accomplished by using pressure, gaskets, or the clamping action of the press.

Design Factors—Component Design: Sheet forming allows wide latitude in design. Deep draws, fine details, undercuts, mechanical inserts, and close tolerances are readily obtained. However, certain considerations should be kept in mind when designing the part.

RADII: Allow liberal radii at the bottom of draws. The minimum should be about ⅛-in., *Fig.* 4.

DRAFT: If a female mold is to be used, ½-degree of draft is usually very satisfactory since the material will shrink away from the mold, *Fig.* 4. In a male mold, however, drafts should be from 1 to 2 degrees, since the material tends to cling to the male plug.

DEPTH OF DRAW: No general rule can be made for the depth of the draw. It should be helpful however to note that in a female mold the greatest thinning usually occurs in the lower corners in the bottom of the draw. In a male mold, on the other hand, the greatest thinning normally occurs in the corners at the base of the plug. Mechanical helpers and snap-back techniques are used

When to Use Vacuum Forming

Vacuum forming of sheet plastics should be considered when . . .

- *The part cannot be molded* by high-production methods because of low per-piece cost requirements and relatively large area needed in a thin-wall design.
- *Impact strength in a thin wall section is necessary.* Most thermoplastic sheet materials have excellent impact strength, even in relatively thin gages. With vacuum forming, ribbing and cross-ribbing a large area to add rigidity and strength is a simple matter. Every formed rib, bead, turned-over rim or change of shape adds rigidity.
- *Limited volume requires a low mold cost.*
- *Frequent design changes occur,* and cost of making a change or doing repair work on a conventional molding die is prohibitive.
- *Production runs are short.* A vacuum-formed part can be set up and production started in less than an hour; a large molded part might require a full day to set up and cycle out properly.
- *Applied decoration is required.* Printing, lithographing or decalcomanias can often be applied to the flat sheet before forming.
- *Certain types of chemical resistance and strength are needed.* Certain thermoplastics, difficult to shape by other methods, can easily be vacuum formed in large-size parts.
- *Mechnical assembly calls for riveting, sewing or cementing.*
- *Minimum residual stress in the part is required.* The sheet-formed part usually (though not always) has less "locked-in" stress caused by the production method than an injection-molded part.
- *Area of the part is larger than can be produced on existing injection-molding equipment.*

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to correct these conditions when excessive.

UNDERCUTS: On many parts, undercuts can be added by the use of a split, movable mold insert, *Fig. 5a*, or by a hinged insert on the mold, *Fig. 5b*. More complex undercut designs usually require an insert which is permanently locked into the part in forming, *Fig. 5c*.

INSERTS: Inserts may be locked into the part in the forming process to provide a complex shape, extra strength where required, or both, *Fig. 6*. In planning a metal insert, it must be borne in mind that the coefficient of expansion of the plastic is several times greater than that of metal. Hence, in cooling or afterwards, a rigidly supported insert may cause cracking and crazing of the sheet. Thus, the design must make due allowances for this important difference. In some cases a nonrigid metal insert may be used. In others, the design may permit a certain amount of movement of the insert.

If the design of the part requires the sheet to fit tightly around a rigid insert, an insert of wood or Masonite is recommended, since in these materials the coefficient of expansion is much closer to that of the plastic sheet.

RIGIDITY: Where added rigidity is required in the part, it is usually a simple matter to add beads, ribbing or rolled edges, all of which greatly improve the stiffness of the part, *Figs. 7* and *8*.

DETERMINING SHEET THICKNESS: A simple formula can be used to determine the approximate thickness of sheet required to form a given part. Multiply the average thickness desired in the part by the total of all areas in the formed part; divide the result by the area of the flat sheet within the clamp on the vacuum forming machine. This will indicate the absolute minimum thickness required in the flat sheet. In most cases this should

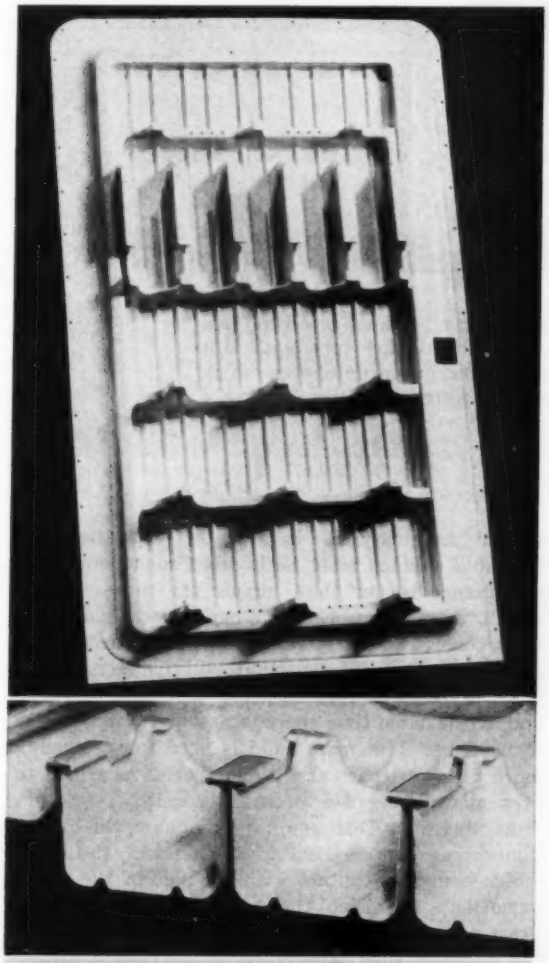


Fig. 6—Permanent wooden inserts are vacuum formed right into this door liner for a Deepfreeze upright home freezer. The vertical racks represent a type of undercut difficult to form with a removable core or plug. Campco rubber-modified styrene plastic, 0.125-in. thick, is reinforced by the Tekwood "orphan" inserts. Insert material was chosen mainly because of similar thermal coefficient of expansion to the plastic

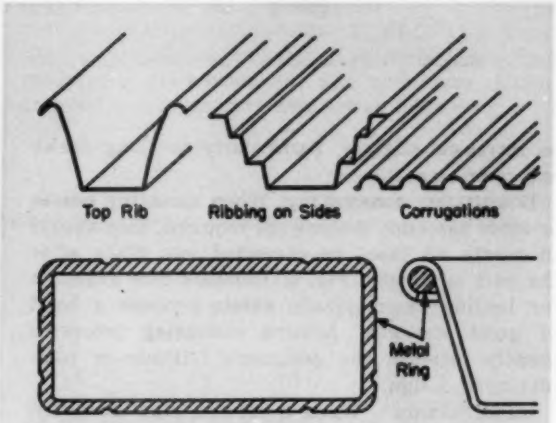
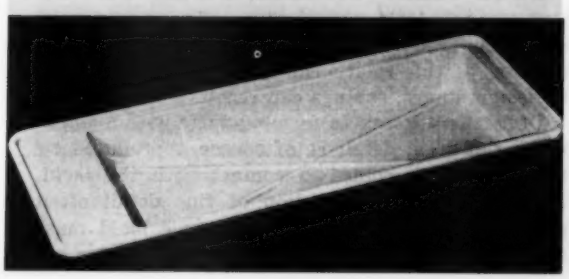


Fig. 7—Above—Methods for adding rigidity to a vacuum-formed plastic part

Fig. 8—Below—Rigidity is attained in this drip tray (Mills Industries Inc.) by a combination of drawing, ribbing and rolling the edges



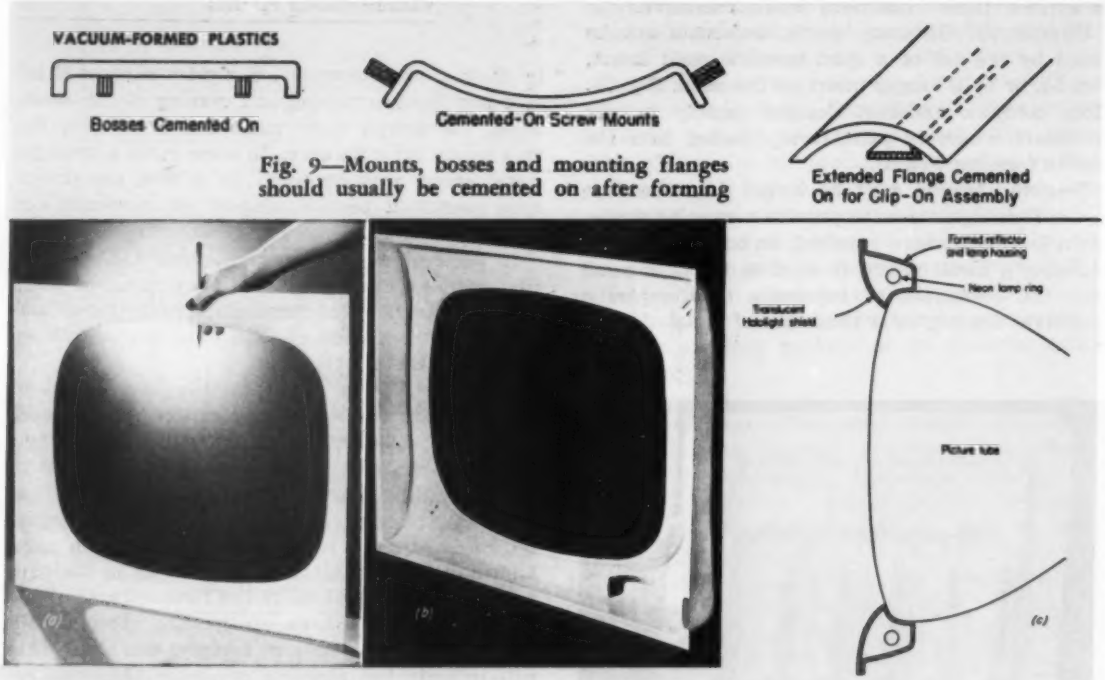


Fig. 9—Mounts, bosses and mounting flanges should usually be cemented on after forming

Fig. 10—Complete Halolight mask assembly for Sylvania television sets is vacuum formed in two pieces. Framing the picture tube with soft light, the neon-light assembly uses a formed translucent polystyrene mask component, *a*, and an opaque rubber-modified styrene reflector housing, *b*

be increased slightly, particularly for long draws and complex parts.

BOSSES AND ASSEMBLIES: When mounting bosses or other assembly mounts are required, they should in nearly all cases be cemented into place after the part is formed, *Fig.* 9. Cements now available for leading thermoplastic sheets produce a bond of great strength. Modern cementing processes greatly increase the designer's latitude in complexity of design.

ILLUMINATION: When a formed part is illuminated from the back, there is definite danger that thinning at corners will cause apparent differences in color. Parts to be illuminated in this manner should be kept simple in design with smooth, flowing lines so that uniform thickness can be maintained in forming, *Fig.* 10.

Design Factors—Production Design: Part design strongly influences the type of mold and mold materials used—in turn influencing cost of production. If this relationship is kept in mind early in design stages, savings can result.

DETAILS ON PART: In forming parts with a single mold, the finest detail is, of course, reproduced on the side which comes in contact with the mold, *Fig.* 11. Therefore, location of fine detail often determines whether a male or female mold must be used, *Fig.* 1. If a high-gloss material is formed so that the glossy side is in contact with the mold, the mold surface must be highly finished in order to enhance rather than impair the gloss.

MULTIPLE PRODUCTION: When several parts are to be formed at one time, female molds are usually preferred. The female mold will usually permit more parts to be formed per square foot of sheet, and at the same time there is practically no danger of webbing. If a male mold is used for producing more than one part at a time, special measures to prevent webbing are often necessary.

ACCURACY OF DIMENSIONS: Obviously, the closest dimensions can be held in the side of the sheet which comes in contact with the side of the mold; variations in sheet thickness occurring in the draw will cause greater variation in dimensions on the opposite side. Therefore, if the closest dimensions must be held on the outside height and width of the part, a female mold is indicated. The male mold would be preferred if the closer dimensions were on the inside of the part.

UNIFORMITY OF THICKNESS: Generally speaking, if the part is generally conical or cup-shaped, more uniform thicknesses can be obtained by using a male mold. When a female mold is indicated for other reasons, however, good uniformity can usually be obtained by the use of carefully designed mechanical helpers in the molding process.

FINISH ON PARTS: Cast resin molds require re-

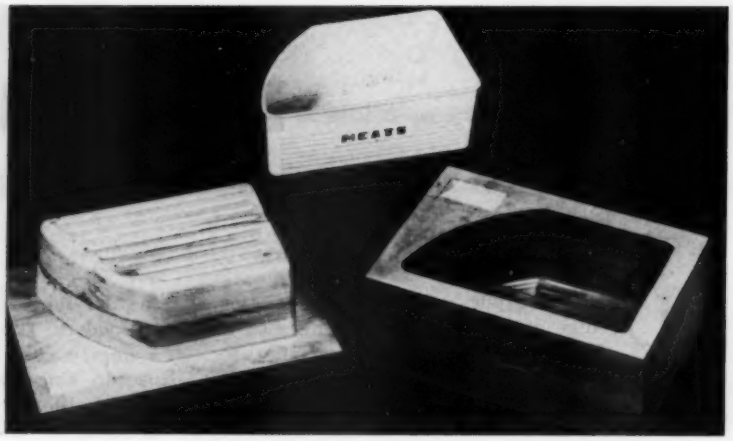


Fig. 11 — Reversing the usual procedure, a female mold was selected for producing this vacuum-formed meat dish, since finest detail had to be obtained on the exterior of the part. The female production mold for the Deepfreeze part was cast around the male wooden mold shown at left. Normally, a male mold would be used because of the depth of draw involved

latively little finishing to produce smooth, finished parts. In cast aluminum, considerably more finishing is required.

SHRINKAGE: Practically all thermoplastic sheet has substantial shrinkage. For example, shrinkage of Campco S-300 rubber-modified styrene sheet is 0.030-in per ft when cooled from forming temperature to room temperature.

Of course, the mold can be—and is—designed to compensate for this shrinkage. But specification of wide tolerances on part dimensions can make this task easier, and possibly eliminate some time charges for finishing the mold.

The situation is further complicated by the fact that a casting shrinkage factor must be allowed for in cast-metal molds—aluminum, for example. No allowance for shrinkage need be made in cast plastic resin molds or in molds made by spraying metal over wood or plaster.

THIN MOLD SECTIONS: Cast resin molds give good results, provided the sections in the mold can be kept fairly substantial. Where sharp folds and similar design details call for thin sections in the molds, molds of aluminum, sprayed metal or machined steel are recommended.

HEATED OR COOLED MOLDS: In some cases the mold should be heated to facilitate forming. In others, the production cycle can be materially speeded up if the mold is cooled. When such heating or cooling is indicated, the mold should be made of a good conductor like aluminum. Resin or wood molds are obviously not suitable.

industrial design ideas

make it "too high"

MACHINE operators are people. This profound statement—original with me—is based not on theory, but on *fact*. But you'd never deduce it from the design of many machines in use today.

Consideration of the machine operator by the designer should result in some welcome improvements. More realistic machine height, for instance.

How high should a machine's working area be? I say "too high"! Design that machine with Long John in mind. Otherwise, you'll either have to jack up the machine for his convenience, dig a hole in the floor for his feet, or sentence him to a stooped operating position that brings on greater fatigue (and a consequent lowering of efficiency and production).

I've wondered for a long time at the standard working height of many production machines. They're not only designed too low to begin with, but this shortcoming is made worse by the fact that most operators, for comfort's sake, usually stand on a wooden platform anyway.

Let's assume that designers don't run machines, but do wash their hands. Next time you use the wash basin, notice how awkward the height is. This is one of my pet hates—so I had those in my house installed 36 inches high. They're wonderful.

Next time you're considering machine height, keep in mind the famous slogan—"no squat, no squint, *no stoop!*"

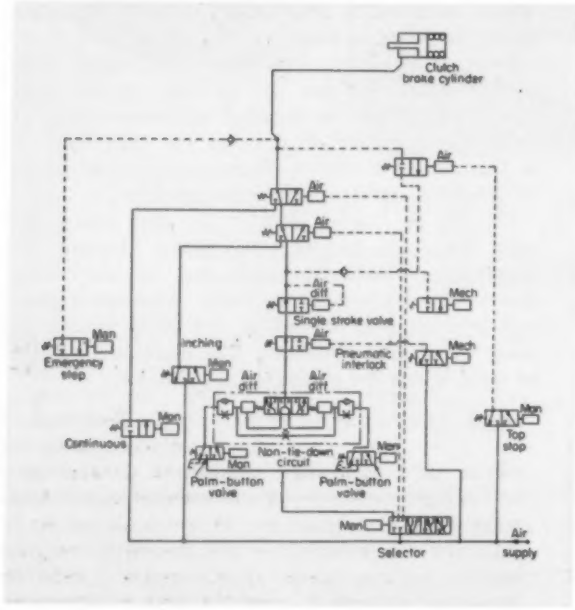
—Cliff

XUM

New All-Pneumatic

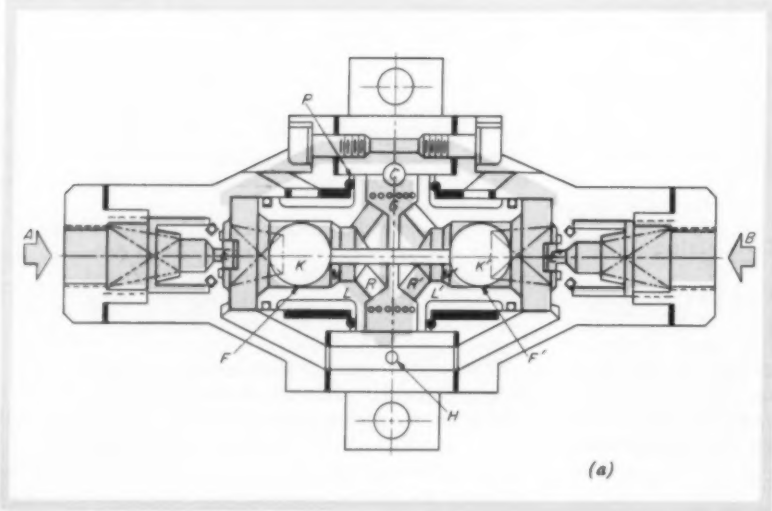
By D. A. DiTirro, *Manager, Research & Development*

USE OF all-pneumatic controls on a machine offers certain advantages to the designer as well as the machine user. A new all-pneumatic circuit for controlling machines requiring two-handed operation for safety reasons has been made possible by the development of two new pneumatic control valves. The valves are a non-tie-down and a single-stroke valve. Primarily designed for use in the control circuits of presses and brakes, the valves and the circuit may also be used on similar machines.



In the control circuit, two palm-button valves are connected between the air supply and the non-tie-down valve. Output of the non-tie-down valve is to a pneumatic interlock valve which is actuated by a mechanically-operated pilot valve. The interlock makes it unnecessary for the machine operator to hold the palm-button valves depressed during the entire operating cycle. From the interlock air is fed to the single-stroke valve and thence to the clutch-brake actuating cylinder.

Components can be added to the basic circuit to provide additional functions such as inching, emergency stop, continuous operation and top stop. Inching allows the machine to be started from and stopped at any position for setup. The continuous operation circuit permits automatic cycling and continuous feed. Top-stop control will stop a press at top dead center after continuous operation. A selector valve is used to preselect the required function.



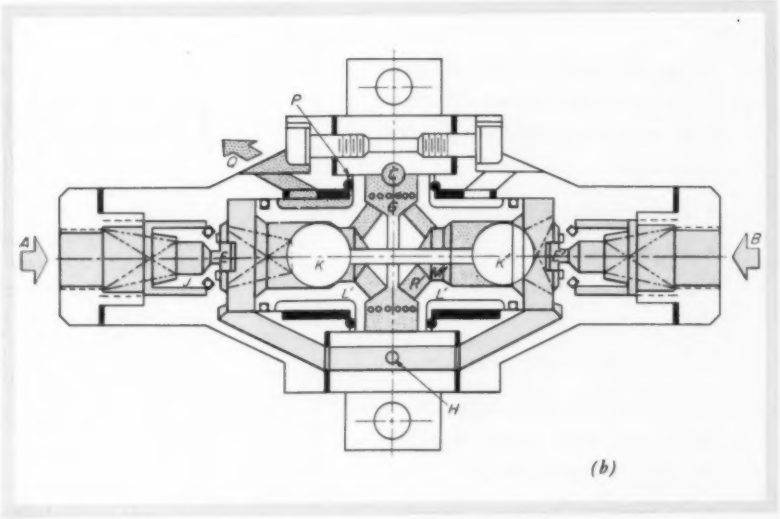
Non-tie-down valve operation under normal operating conditions is shown at *a*. Air enters through ports *A* and *B*, passes through orifices *E* and *E'*, through passages *F* and *F'* and through passages *R* and *R'* to the working system via port *C*. Symmetrical design of this valve makes it necessary for the operator to energize and release both palm-button valves supplying input air to the valve for each cycle. An adjustable sensitivity control, *H*, integral with the valve can be set to require simultaneous actua-

Control Circuit

Ross Operating Valve Co., Detroit

tion of the palm buttons or provide varying degrees of lag time.

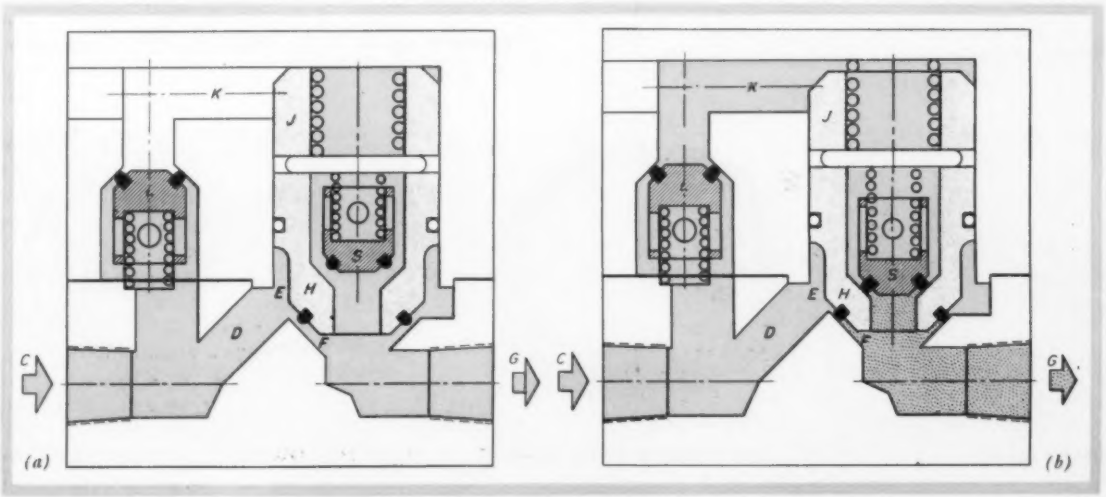
An attempt to tie down one of the palm buttons and then actuate the other causes air to be exhausted from the non - tie - down valve instead of being supplied to the press-operating circuit. As shown at *b*, tying down the palm button supplying air to port *A* creates pneumatic unbalance in the valve, causing poppet *K* to seat and unseat the connected poppet *K'*. When poppet *K* is seated, pressure unseats poppet *L* connecting chamber *G* to exhaust port *Q* through passage *P*. Actuation of the other palm button allows air entering port *B* to be exhausted to the atmosphere.



(b)

Single-stroke valve air inlet is from the non-tie-down valve. During operation air enters at port *C*, then passes through passage *D* to poppet *H*. Pressure then unseats poppet *H*, opening passage *F* and allowing air to enter working system through port *G* as shown at *a*.

As pressure builds up in the working system, poppet *S* opens allowing pressure to build up in the cavity, *K*, above and surrounding poppet *S*. Presence of pressure in the cavity allows the springs to move poppets *H*, and *S* downward and close them. Poppets *H*and *S* remain closed as long as inlet air is supplied to port *C*, *b*. This isolates the outlet port from the inlet port and permits a small cam-actuated valve to exhaust pressure on the outlet side of the valve when the working stroke is completed. When pressure is removed from the inlet port by releasing the palm buttons, air under pressure in chamber *K* exhausts through check poppet *L* and the palm button valves. This clears the valve for the next operating cycle.



XUM

Fastening and Joining

Tungsten and titanium carbides are well-known for several unique properties useful in design:

- Exceptional wear resistance
- High rigidity and stiffness—two to three times that of hard steel
- Strength in compression
- Ability to resist high temperatures with good strength at these temperatures
- "Slippery" bearing characteristics against iron or copper alloys, with low galling or welding tendencies

But the price paid for these excellent characteristics is special attention to joining or assembly. Fastening and joining carbides to steel and other metals present a few problems. This article gives many of the answers.

DESIGN methods for fastening or joining the carbides must take certain properties into account. Since carbides have a high modulus of elasticity, deflection must be held to a minimum to avoid fracture. They are notch sensitive. Thermal expansion is very low compared with steel; extreme service or brazing temperatures cause problems in differential expansion.

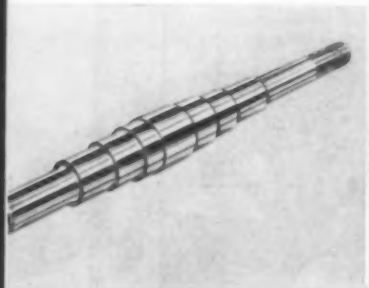
Successful techniques have been worked out to answer almost all of these design problems. These techniques are presented here for the three main methods of fastening and joining carbides: (1) brazing, (2) cementing, and (3) mechanical fastening.

Brazing

Brazing is quite satisfactory for small-area, short-length joints and, through the use of certain design principles, can be applied satisfactorily to larger joints.

The tungsten-base carbides are readily "wet" by brazing alloys ranging from silver solder to pure copper. The titanium-base carbides, however, are somewhat more difficult to wet. Where the titanium carbides must be mounted by brazing or soldering, the required surfaces must be prepared by providing a metallic coating which is fired onto the titanium carbide surface. This in turn is readily wet by the common silver solders, bronze alloys or copper.

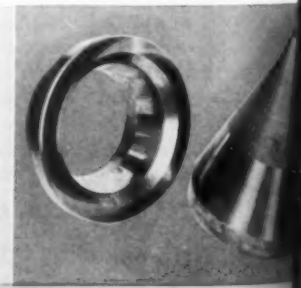
Thermal Stress in Brazing: Thermal expansion



SOLID SHAFT

GAS-TURBINE VANE RING

CAM FOLLOWERS



VALVE CONE AND RING

CARBIDES

By W. L. Kennicott, *Chief Engineer*

Kennametal Inc., Latrobe, Pa.

rates of hard carbides vary roughly from ⅓ to ½ that of steel. *Fig.* 1 shows the problem involved when a piece of carbide with low thermal expansion rate is bonded by fusion of a brazing material to a strip of steel.

At the solidification temperature of the brazing material, the two strips are unstressed and are straight and parallel. As the joined strips cool, the steel contracts about twice as much as the carbide thus causing the bimetal strip to bend. The sketch in *Fig.* 1 is, of course, exaggerated; the carbide would pass its elastic limit and be broken before any such curvature could be accommodated. Of course, if both the carbide and steel are thick enough to resist bending, a residual stress will be caused.

Expansion and contraction rates of SAE 1095 steel, a typical titanium-carbide alloy, and several of the tungsten-base carbide alloys are shown in *Fig.* 2. Two low-expansion nickel alloys are also plotted for comparison. Because of a transformation or phase change, the curve for steel is different for the cooling cycle than for the heating cycle. The carbides, having no phase changes, expand and contract at a uniform rate.

Relative amount of thermal stress across a carbide-to-steel brazed joint is represented by the distance from the expansion line for the carbide to the expansion line for the steel at the temperature where the braze material freezes. Thus, a preferable braze temperature can be selected from the curves. Vertical line *A* at about 1200 F represents the solidification point of a common silver-soldering alloy. Line *C* takes advantage of a

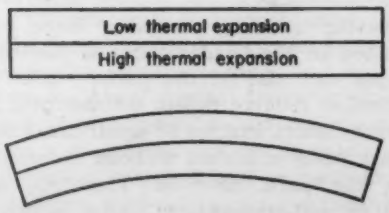


Fig. 1—As brazed assembly of carbide and steel cools from brazing temperature, differences in thermal expansion cause stress and bending in the joint

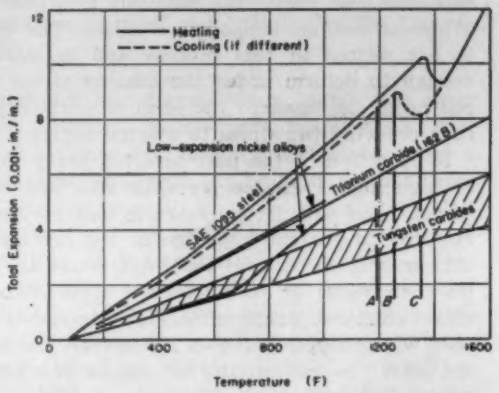
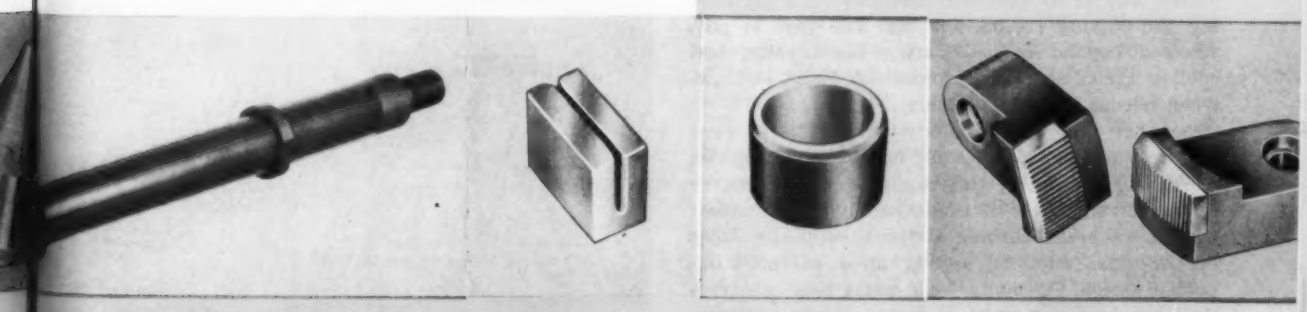


Fig. 2 — Above — Thermal expansion curves for carbides, steel and low-expansion alloys can be used to select a brazing temperature range



SOLID QUILL SAW GUIDE BUSHING CHUCK JAWS

low point in the steel cooling curve to reduce the distance between the curves. This 1350 F temperature would be an advantageous freezing point for a brazing alloy. Line *B* at 1250 F, however, would be the least desirable freezing point. Evidently, solidification temperature of the brazing material should be at or close to 1350 F, or else below 1200 F to hold brazing stress to a minimum.

Other factors may affect this picture. For instance, an alloy with high malleability—even though it has a high-temperature freezing point —may actually have less final stress after cooling to room temperature.

Relieving Brazing Stresses: Since curvature permitted in the bonded parts is limited by the stiffness and size of the parts, stress must be absorbed or relieved within the assembly. Stresses set up by short lengths or small areas are minor and are easily absorbed without materially weakening the parts involved. Therefore, a simple braze of well-proportioned parts, not excessively long or of large area, is commonly used on small carbide inserts. On longer joints, the stress becomes proportionately greater and other methods of construction must be considered.

SANDWICH BRAZE: Brazing stresses may be relieved somewhat by a sandwich braze, *Fig.* 3, which consists of a copper shim between the carbide and steel parts. The assembly is brazed with a low or medium-temperature solder. The copper is not melted in this process and is malleable enough to deform under the brazing stress without losing its bond to the steel or carbide parts, thus relieving the stress to a large degree.

If operation of the part involves heavy loading or high impact, the copper shim will beat out or "mush" and will not provide the uniform support required to prevent breakage of the carbide. For this reason, the copper sandwich braze is useful only on light or medium-duty applications. A nickel shim will stand more pounding and is often used where copper is too soft. However, nickel does not have the malleability of copper and will not relieve the stresses as effectively as copper.

COUNTERSTRAINING: Since a good brazed joint seldom fails in shear, tensile stress can be reduced in the outer edge of a carbide strip by forcibly overcoming the curvature of the assem-

One way is to hold the assembly in a jig during the cooling period, *Fig.* 4*a*. The part is prestressed beyond normal during the brazing and cooling cycles so that it comes out about straight when released from the fixture.

Another way to overcome curvature is to peen the steel surface opposite the brazed joint, *Fig.* 4*b*, expanding it and setting up a counterstress to restore straightness of the assembly. Still another way is to braze carbide strips to opposite faces of the steel, *Fig.* 4*c*, setting up a balanced opposing stress. On many wear parts this construction provides not only a counterstressed assembly, but one with two wear faces which can be indexed into position as required.

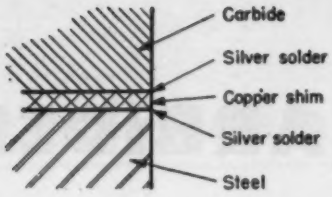


Fig. 3—Sandwich braze relieves brazing stresses by deformation of the copper shim

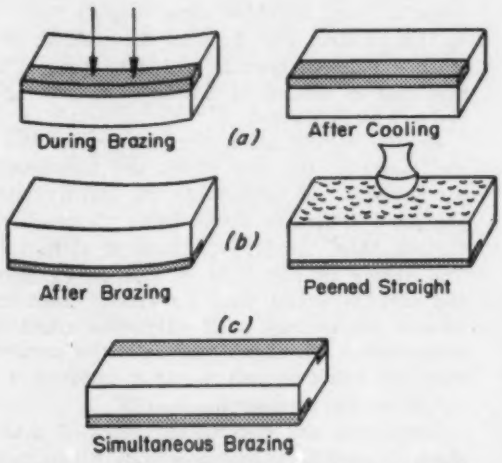


Fig. 4—Counterstressing a brazed joint leaves residual stresses in the joint, but straightens the assembly. Three methods are: *a*, prestressing during brazing and cooling, then releasing to straighten; *b*, allowing to warp during cooling, then peening to straighten; *c*, simultaneously brazing an opposing carbide piece to balance the stress

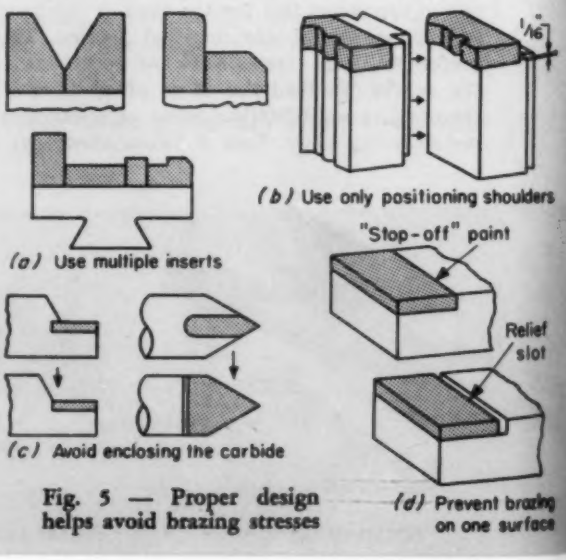


Fig. 5 — Proper design helps avoid brazing stresses

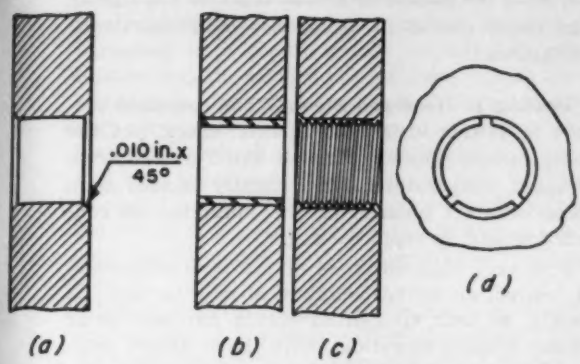


Fig. 6—Thin-wall steel sleeve brazed into a carbide hole permits threading. Sharp corners on carbide are chamfered, *a;* the sleeve is brazed, *b;* and threads are tapped, *c.* Segmenting the sleeve, *d,* helps relieve brazing stresses

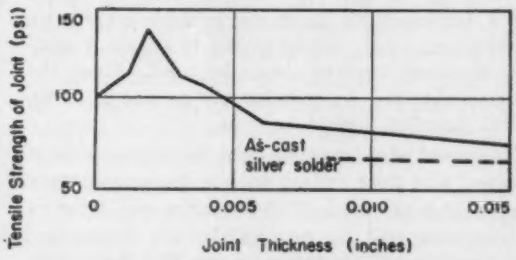
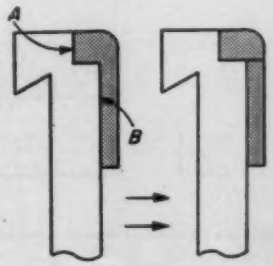


Fig. 7—Strength-thickness curve shows optimum thickness of a silver-solder brazed joint

Fig. 8—Single piece of carbide cannot be brazed properly to *A* and *B* surfaces. Two-piece construction permits each piece to seat properly



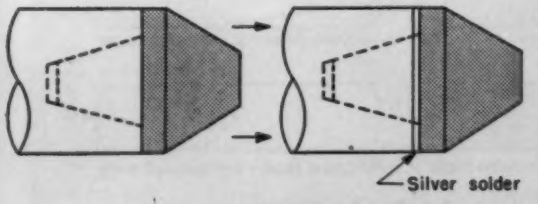


Fig. 9—To insure full seat on a taper, a gap is left, then brazed closed after the carbide is seated

With any of these counterstressing methods, the assembly should be allowed to stand for a few hours (or even a few days) before finish grinding, since the stresses are still locked in and some creep may take place.

STRESS-RELIEF HEAT-TREAT: A small amount of stress can be relieved by soaking the assembly at temperatures up to 400 F, but in order to remove major stresses such as encountered in braze joints over 1 in. long, it would be necessary to soak at temperatures of 1050 F or above. Since this is just below the temperature at which silver solders solidify, the cooled assembly is again stressed to about the same degree after cooling.

DESIGNING TO AVOID STRESS: Use of a series of short pieces of carbide will reduce the cumulative effect of brazing stresses, *Fig.* 5*a*. In this manner distortion can be controlled, and an assembly can often be designed with joints at noncritical points on the edge or surface. In other cases, well-fitted joints can be used which will not interfere with the operation of the composite part, *Figs.* 5*b* and *c*.

Stresses may often be relieved on a badly proportioned assembly by brazing only on one surface, *Fig.* 5*d*. A chalk-like "stop-off" paint can be applied to the surfaces on which no bonding is wanted so that the braze alloy will not wet those surfaces, or a relief gap can be left in the assembly.

Shrink-Brazing Rings: Rings or circular parts present additional problems in mounting. A steel ring or cylinder is frequently mounted around a carbide core. The parts can be sized so that there is an interference fit at room temperature, but brazing can still be accomplished at an elevated temperature. The steel outer ring will be in tension, providing a combination of shrink fit and brazed joint. Even if clearance is allowed for assembly at room temperature, solder will fill the void and the final effect will be a shrink-braze combination.

On the other hand, a carbide ring around a steel core presents an entirely different problem. If this combination is sized for a normal braze thickness at room temperature, the steel will expand more than the carbide while being heated up for brazing. This expansion will either cause a tensile fracture in the carbide ring or, if assembled after heating, the steel part will be too large.

If the combination is sized for a slip-fit assembly at brazing temperature, the steel in cooling will tend to pull away from the carbide core, thus breaking the braze joint or fracturing the carbide. Unless the steel liner can be light enough to flex with the carbide, this combination cannot be brazed and must be designed for some other method of mounting.

A special application of the thin-wall steel bushing is shown in *Fig.* 6. The purpose of the bush-

ing is to provide threads in a carbide block, *Table* 1. The bushing walls are so thin that the subsequent tapping operation virtually cuts through the steel and the remaining steel section is not strong enough to cause cracking.

Joint Thickness: Thickness of a brazed joint is critical in assemblies of carbide and steel. The thicker the braze layer, the more readily it can absorb thermal strain. But as the braze becomes thicker, it is more likely to fail due to peening out or for lack of physical strength.

When the brazing alloy is stressed, it tends to elongate before failure. This elongation requires a reduction in area which, in turn, is restrained in the joint by the closely spaced hard faces of the steel and carbide to which the brazing alloy is bonded. Thus, the brazing alloy resists elongation not only by the shear strength or tensile strength of the brazing material itself but also by resistance to simultaneous flow in several directions.

Result is that a thin brazed joint can have several times the tested tensile strength of the as-cast brazing material. For example, using silver solders in bonding hard carbide to reasonably hard steel, a braze thickness of 0.0015-in. will produce a joint tensile strength of 130,000 psi, although the tensile strength of the silver solder itself is only about one-half that amount. As the silver-solder thickness increases, the tensile strength of the joint falls, *Fig.* 7. At about 0.015-in. thickness the tensile strength of the joint is about equal to the tensile strength of the silver solder.

Thus, a brazed joint that is excessively thin can bond the dissimilar metals together too tightly and cause cracks in otherwise well-proportioned assemblies.

Brazing to Hardened Steel: While cemented carbide is quite resistant to thermal shock, yet the same carbide will not stand a liquid quench from elevated temperatures when tightly bonded to a piece of steel because of the difference in contraction during rapid cooling.

If a very high hardness of the steel component is desired, an air-hardening steel may be used. It should be heat treated to obtain hardness prior to any brazing operation. With the structure properly established, it can then be reheated to recommended hardening temperature again for a short period of time, brazed with a suitable brazing alloy for that temperature and air cooled. The assembly can then be drawn to required hardness of the steel. A single heating is not generally satisfactory, except on small parts, since the time required at temperature for proper heat treating is excessively long for a suitable braze operation.

If a intermediate hardness is satisfactory, an oil-hardening steel—air quenched to obtain a moderate hardness reading—may be used. Since the hardness obtained depends largely on size of parts, several samples should be run.

High-speed steel may be used for components if hardened and then brazed with a low-temperature silver solder at about 1200 F maximum. Most of the hardness will be retained by the high-speed steel member at this temperature, and the result-

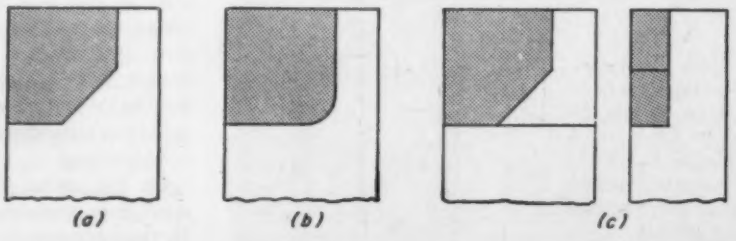


Fig. 10—Tip cannot fit all three shoulder surfaces at *a*. Redesign to nonconflicting shoulders helps, *b*, but removing shoulder and brazing only on bottom and one end, *c*, is best

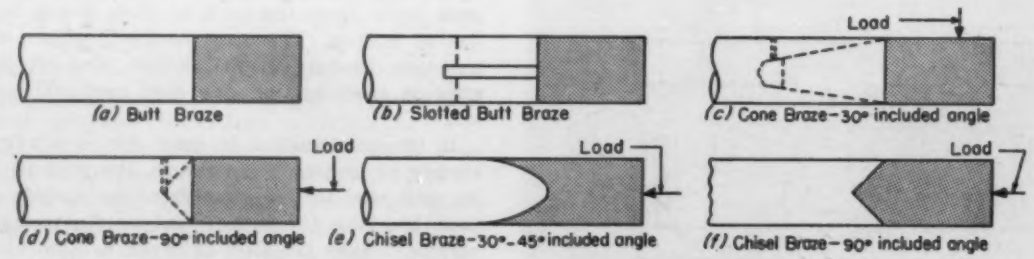


Fig. 11—Various directions of force can be handled by different joint designs. Butt braze, *a*, is satisfactory only on small-diameter parts. Slotted butt braze, *b*, permits the four pads to deflect as the braze cools. Joint *f* can be used on rectangular or round parts

ing combination is suitable for many uses.

If the steel does not have to be hardened adjacent to the carbide, a steel part may be partially immersed in a liquid coolant immediately after brazing, but the carbide portion must remain above the surface. It is necessary to heat the entire steel part, or a substantial portion of it, rather than localizing the heat at the brazed joint.

A few small and simple shapes may be liquid quenched entirely from the brazing heat to solidify the braze and harden the steel simultaneously. Only simple shapes may be quenched in this manner.

Many air-hardening steels contain substantial percentages of chromium. This complicates brazing since the oxide of chromium which forms on the steel is difficult to flux away. Wherever possible, a nickel-base air-hardening steel rather than chromium-base should be used.

Shape of Brazed Joints: In design of a brazed joint a single brazing surface is preferable to reduce stresses. However, such a joint is not always feasible. Where more than one surface is to be brazed simultaneously, the design should be such that the carbide slides along one surface until it engages or abuts a second surface. When three surfaces must be engaged, the joint should be designed so the carbide will slide along one surface until it shoulders against a second, then move along the two surfaces until it abuts the third surface for position.

Attempting to braze two surfaces which are parallel to each other but not in the same plane will invariably result in (1) one of the brazed joints being excessively thick, or (2) excessive thermal stress because the relation of the two surfaces is not constant during the cooling cycle. *Figs.* 8 through 10 illustrate the use of this principle.

The shape of a brazed joint should help the assembly resist the expected forces when the part is put to use. As an example, a carbide working end on a round rod might be subjected to compression forces, as in a push pin; lateral thrust, as in a composite shaft; torsion, as in a roll; or tension, as in a tube-drawing mandrel. The most desirable shape of brazed joint will vary accordingly.

Several joint shapes for resisting these various directions of forces and the reasons for using them are shown in *Fig.* 11. Conical brazed joints incorporate a vent-hole to permit exit of gas pockets, flux or excess braze material which might otherwise become trapped and prevent proper control of braze thickness.

Table 1—Bushing Sizes for Inserted Threads

Thread Size	Molded Hole Size (+0.006, −0.000)	Bushing OD (±0.001)	Bushing ID (Standard tap drill)
	All dimensions are in inches		
5-40	0.136	0.131	0.1015
5-44	0.136	0.131	0.1040
6-32	0.150	0.145	0.1065
6-40	0.150	0.145	0.1130
8-32	0.176	0.171	0.1360
8-36	0.176	0.171	0.1360
10-24	0.203	0.198	0.1495
10-32	0.203	0.198	0.1590
12-24	0.229	0.224	0.1770
12-28	0.229	0.224	0.1800
¼-20	0.263	0.258	0.2010
¼-28	0.263	0.258	0.2130
5/16-18	0.327	0.321	0.2570
5/16-24	0.327	0.321	0.2720
⅜-16	0.390	0.384	0.3125
⅜-24	0.390	0.384	0.3320
7/16-14	0.453	0.447	0.3680
7/16-20	0.453	0.447	0.3906
½-13	0.516	0.510	0.4219
½-20	0.516	0.510	0.4531
9/16-12	0.579	0.573	0.4844
9/16-18	0.579	0.573	0.5156
⅝-11	0.643	0.636	0.5312
⅝-18	0.643	0.636	0.5718
¾-10	0.870	0.862	0.6562
¾-16	0.870	0.862	0.6875

Cementing

Use of carbide for wear-resistant applications has greatly increased with the recent development of epoxy resins for metal-to-metal bonding. These adhesives have sufficient strength, and a low enough bonding temperature to eliminate thermal stress created by bonding. With the new epoxy resin adhesives, carbide can be applied to much larger areas in one piece than previously, primarily because of the low curing temperatures. Limitations are temperature (strength drops rapidly above 250 F) and bond strength (8000 psi compared to brazing at 70,000 psi and up).

A large number of adhesives are available. However, the classification of primary interest is the metal-to-metal group. Within this classification there are adhesives that establish a bond at 68 to 85 F (room temperature setting), at 85 to 250 F (intermediate temperature setting), and at over 250 F (elevated temperature setting).

In a further breakdown, some adhesives require the addition of a hardening agent, often referred to as a catalyst or activator, and some require only heat to obtain the bond. Each of these materials has a definite place in its respective field. But main interest is in the thermosetting adhesives because of the higher strengths achieved.

Mechanical properties of different "equivalent" adhesives show a radical variation. Shear strength, as an example, may vary from 2000 to as high as 8000 psi.

Other important properties of the adhesives from a production standpoint are the necessary preparation, the pot life and the shelf life of the material. Adhesives which do not require the addition of a hardener seem to have advantages in all three respects.

The best and the most consistent results in bonding carbide to steel have been achieved with powder and stick forms, since only temperature is

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required for adhesion. Adhesives of these types require preheating the part prior to assembly of faying surfaces. One liquid type does not require preheating and produces bonds only slightly lower in shear strength.

Although heat is required for curing the resin, a large temperature range is acceptable, with lower temperatures requiring longer exposures. Some advantages of this type of epoxy resins are:

1. No additional hardeners are required.
2. Storage life at room temperature is very good.
3. Wetting characteristics to metals are excellent.
4. Resins can be readily bonded to many materials such as plastics, ferrous and nonferrous metals, ceramics, glass and wood.

In repeated tests of bonding carbide to steel, shear strengths of around 8000 psi have been obtained.

As mentioned previously, bonding of metals with different thermal expansion coefficients at elevated temperatures involves thermal stress or distortion during cooling. In the relatively low temperature range of 250 to 450 F, larger areas can be bonded in one piece with less inherent stress.

The joint should be from 0.003 to 0.006-in. thick to assure maximum strength in the bond. The faying surfaces should be clean and free of all dirt, grease and scale. A liquid cleaner such as carbon tetrachloride will remove grease and any oily type dirt, but grinding or sandblasting are best for removing oxides or scales.

When the stick form of adhesive is used, the parts should be preheated to 250-300 F. The powder form can either be dusted on cold surfaces and then heated, or it can be dusted on a preheated area. Although pressure on such joints is not absolutely required, joints of more constant thickness and higher strength are obtained by clamping.

Mechanical Fastening

Both brazing and cementing have limitations. The brazing method can be used only under certain conditions because of the temperature problem involved in assembly. The cementing method is limited by a narrow operating temperature range. Mechanical mounting of carbide overcomes these difficulties and, in many cases, provides the most desirable design advantages.

Since there is no bonding temperature requirement, thermal expansion problems are limited to the temperature range in which the assembly is expected to operate. When operation is within a very limited temperature range, no allowance need be made for the difference between the thermal expansion rate of carbide and that of the steel or other material used in making up the part. Even when temperature range is somewhat wider the slight movement between the carbide and steel can be accommodated in design without setting up a residual stress.

Another big advantage to mechanical assembly is that the steel parts may be heat-treated to the desired hardness, and mounting surfaces can be finished after hardening to provide a more durable assembly. Since steel mounting surfaces can be so finished, and the carbide surfaces can be ground to match, better fits and better distribution of load are possible.

If loads are exceedingly high, the working or expendable piece of carbide can be kept small by seating it on a carbide shim or backup to provide the rigidity and contour necessary to support the working piece of carbide.

Design Fundamentals: In design of a mechanical mounting, certain principles must be followed for best results:

1. To get maximum support, clamp in the same direction as the operating thrust and support the load against solid, hard, carefully fitted supporting surfaces. Clamping is just for holding.

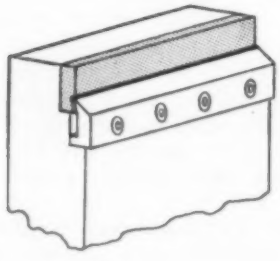
2. Carbide has a low coefficient of friction against steel. Movement must be prevented either by positive stops and shoulders or by higher contact pressures between the surfaces than would be necessary between two steel surfaces.

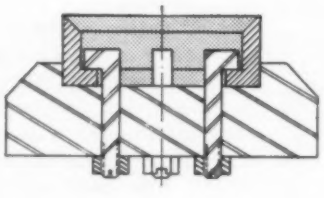
3. Assemblies should be designed to take advantage of the extremely high compressive strength of the carbide. Notches should be avoided on highly stressed parts since carbides are more notch-sensitive than most materials.

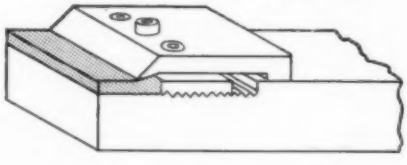
Within the area bounded by these principles, a wide variety of fastening methods can be used. Some of the most common are shown in the following section.

Clamp Mountings

The simplest type of mechanical mounting is with a clamp. The carbide element is generally fitted into a nest or supporting recess, then held in place by one or more clamps.

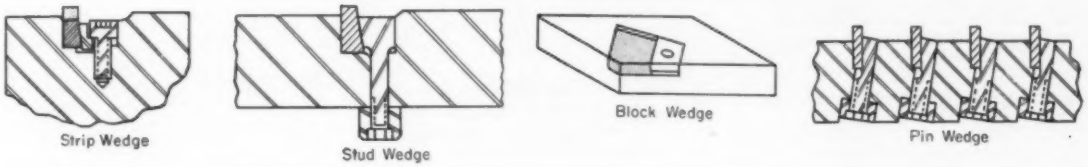






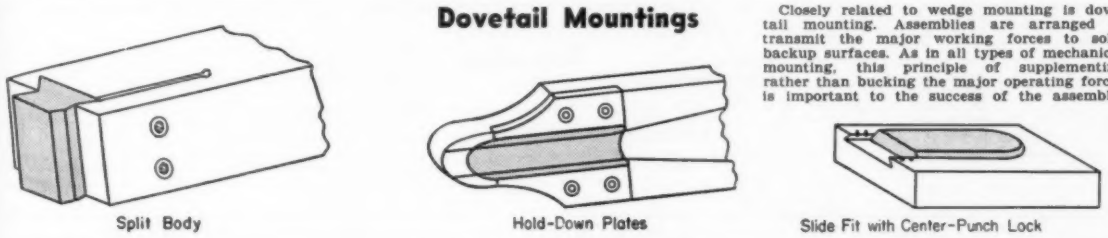
Wedge Mountings

When the carbide part is to be held in place in a slot or recess, wedging is often more practical than clamping. Wedges can be designed for much tighter holding than clamps. When longitudinal movement of the carbide in the slot or recess must be prevented by friction alone, the higher pressures of wedging are a definite advantage. The pin wedge, which is simply a notched round pin in a drilled and reamed hole, provides a simple holding method that can be fitted into a very small space.



Dovetail Mountings

Closely related to wedge mounting is dovetail mounting. Assemblies are arranged to transmit the major working forces to solid backup surfaces. As in all types of mechanical mounting, this principle of supplementing rather than bucking the major operating forces is important to the success of the assembly.

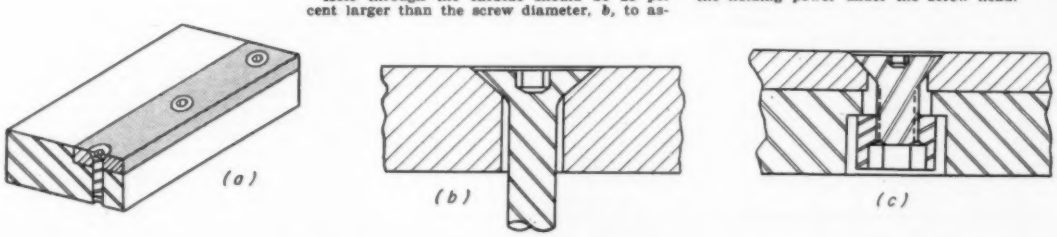


Countersunk Screw Mountings

If holes are to be put in the carbide prior to sintering, the spacing will vary somewhat, *a*. To assure proper alignment of the countersunk holes and the tapped holes in the steel body, the carbide part may be used as a drill jig to position and align the tapped holes accurately.

Hole through the carbide should be 25 per cent larger than the screw diameter, *b*, to assure seating on the cone.

Another way to align the holes is to use a nut in an oversize counterbore, *c*, so the screw and nut floats or shifts to accommodate variations of center-to-center distance in the carbide. This construction is practical on relatively thin carbide strips without weakening the holding power under the screw head.

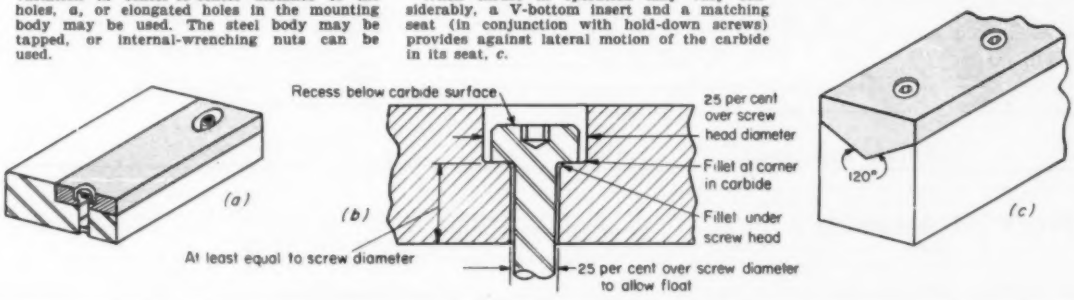


Counterbored Screw Mountings

When a thicker carbide section is permissible, a counterbored hole for a heavier screw head may be used. All but one of the counterbored holes can be elongated to permit variation in center-to-center distance of the holes, *a*, or elongated holes in the mounting body may be used. The steel body may be tapped, or internal-wrenching nuts can be used.

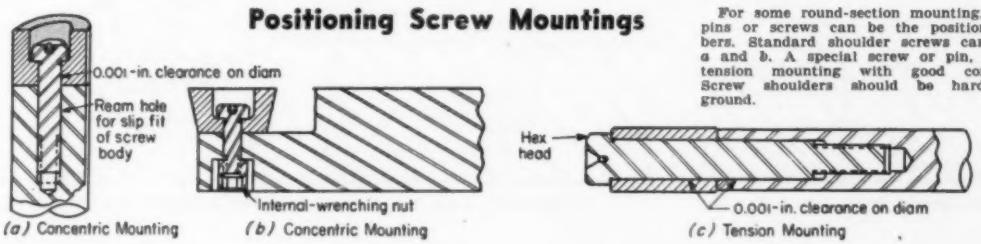
Whenever counterbored holes are used, certain precautions are required to assure best possible strength and eliminate highly stressed sharp corners, *b*.

When thrust in operation may vary considerably, a V-bottom insert and a matching seat (in conjunction with hold-down screws) provides against lateral motion of the carbide in its seat, *c*.



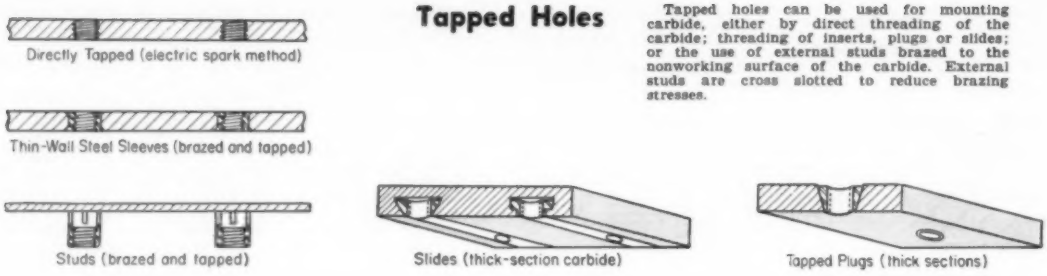
Positioning Screw Mountings

For some round-section mounting, mounting pins or screws can be the positioning members. Standard shoulder screws can be used, *a* and *b*. A special screw or pin, *c*, permits tension mounting with good concentricity. Screw shoulders should be hardened and ground.



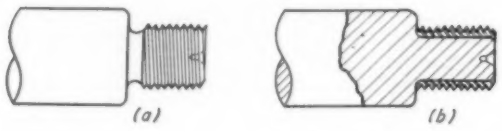
Tapped Holes

Tapped holes can be used for mounting carbide, either by direct threading of the carbide; threading of inserts, plugs or slides; or the use of external studs brazed to the nonworking surface of the carbide. External studs are cross slotted to reduce brazing stresses.


Directly Tapped (electric spark method)
Thin-Wall Steel Sleeves (brazed and tapped)
Studs (brazed and tapped)
Slides (thick-section carbide)
Tapped Plugs (thick sections)

Threaded Pins

Threads can be produced on the ends of carbide pins or bars, either by grinding threads directly into the carbide, *a*, or by brazing a thin-wall steel bushing over the carbide rod and cutting the threads into the steel bushing, *b*. Either method is quite satisfactory. The brazed bushing is generally preferred from a cost standpoint, and also because it eliminates notches in the carbide.



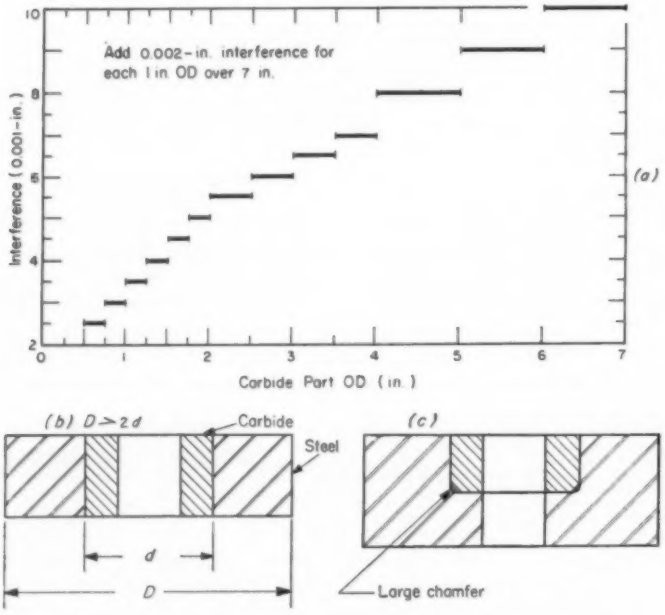
Shrink Fit Assembly

A convenient method of mounting round sections of carbide in steel is by an interference. For maximum holding power, the interference should be as shown in graph *a*, and the steel casing or holder should be at least twice the diameter of the carbide, *b*. This amount of interference requires a temperature differential for assembly—a shrink fit. For lesser holding power, a reduced amount of interference can be used.

Concentric, uniform-section assemblies, *b*, will distribute the holding stresses uniformly. However, when inserts are mounted into counterbored cavities or round inserts are mounted into rectangular bodies, *c*, stresses are unequally distributed and large chamfers are necessary to prevent excessive concentration of forces at the edge.

Steel for shrink assemblies must be properly selected and treated for best holding. A steel with at least 15 per cent elongation and 150,000 psi yield strength at 35-40 Rockwell C will hold tightly without danger of fracture. Where shrink assemblies are used, the draw temperature for this hardness should be at least as high as that required for assembly. The fits in graph *a* are readily assembled with the steel at 800 F and the carbide at room temperature. Most oil-hardening tool steels, and alloy 0.40 per cent carbon steels such as 4340, can be heated to 800 F without softening below the desired 35-40 Rockwell C hardness.

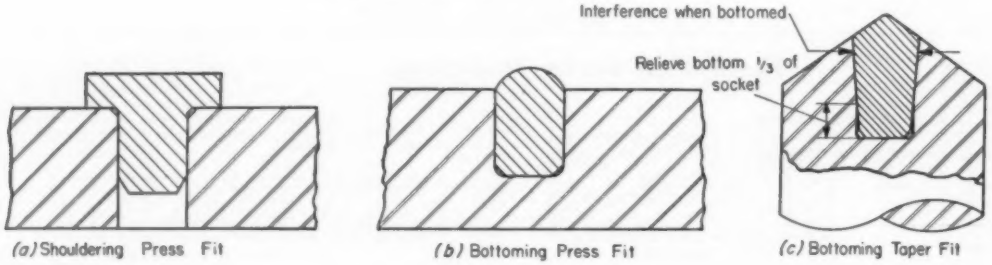
Applications involving high temperature during operation will tend to loosen the holding forces, since the steel body will expand two to three times as much as the carbide and reduce the interference.



Press Fit Assembly

Closely akin to the shrink fit assembly is the press fit. Lesser interferences permit assembly without biting into the steel wall of the recess. Steel requirements are much the same as far as elongation and yield strength are concerned, but the draw temperature is no longer critical.

Pressing a pin into the steel recess, *a* or


Interference when bottomed
Relieve bottom 1/3 of socket
(a) Shouldering Press Fit
(b) Bottoming Press Fit
(c) Bottoming Taper Fit

b, requires a taper chamfer to lead the pin into the hole properly. Wear pads or points can thus be pressed into critical surfaces of assemblies and parts of steel, iron, aluminum, etc.

Bottoming taper assemblies, *c*, should be calculated to provide the same interference when bottomed as would be allowed in a shrink-fit assembly. This construction is highly satisfactory for parts and tools taking impact on the carbide. Relieving the steel near the bottom of the hole eases the shear stress in the steel body. Taper should not exceed a 10 degree included angle. The steel body will best withstand continued impact if made of a tough 0.25 per cent carbon alloy steel, carburize case-hardened deeply in the socket and on the driving surfaces to prevent peening.

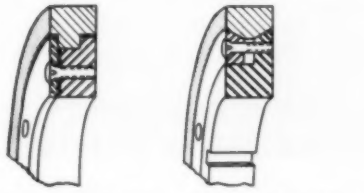
Additional radial forces to hold a carbide liner in compression, even when subjected to high internal forces, can be provided by using a double case. With this method a relatively thin-wall case can be pressed over the carbide liner, and then pressed or shrunk into a thicker second case. Total radial forces can thus exceed those possible within the elastic limit of a single heavy-wall case.

External Ring and Sleeve Mounts

External carbide sleeves or rings mounted on steel, iron or low-expansion alloy arbors are usually more economical than solid carbide. To avoid hoop tension in the ring or sleeve, it should be mounted with axial clamping, *a* and *b*.

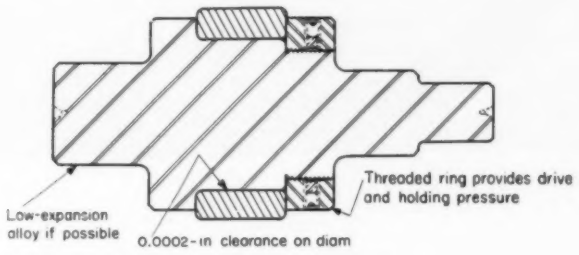
If working loads are principally radial, no positive keying is needed, *c*. However, in applications involving high torsion, such as driven rolls, a positive key drive is necessary. When positive drive is used, *d*, a lug is put on the carbide rather than a keyway. Since the carbide is notch-sensitive, the lug drive is more dependable.

For simple wear rings, a loose but positive lock that will allow repeated expansion and contraction can be made by using a groove and wire, *e*.

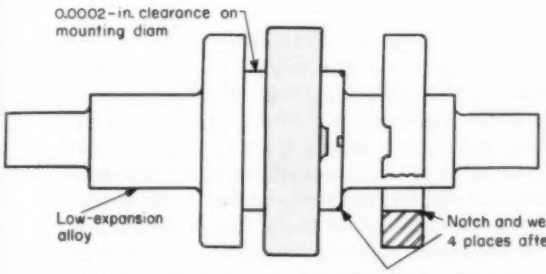


(a) Tongue-Mounted Ring

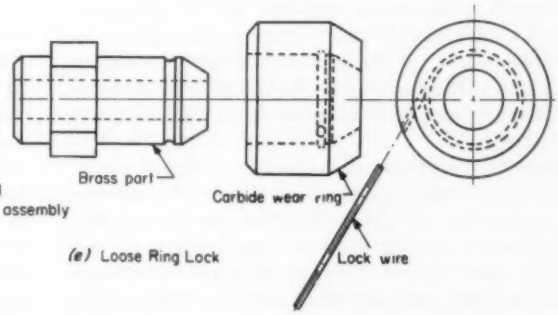
(b) Bevel-Mounted Ring



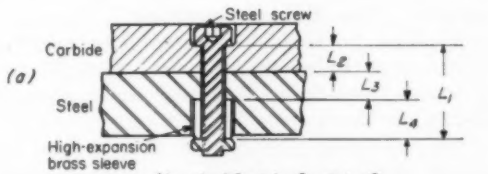
(c) Arbor-Mounted Roll Ring (radial thrust)



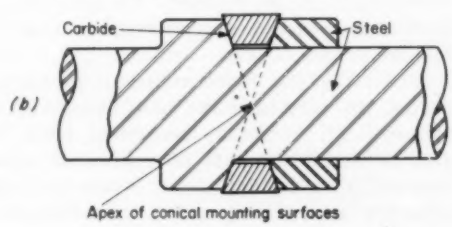
(d) Arbor-Mounted Roll Ring (torsion and radial thrust)



(e) Loose Ring Lock



$$(L_1 - L_3)\,\epsilon_s = L_2\,\epsilon_c + L_4\,\epsilon_b$$



Expansion Joints

Mechanical assemblies of carbide and steel involving considerable temperature range or extreme accuracy of surfaces can be designed to accommodate relative movement between parts caused by temperature changes without losing alignment, concentricity or accuracy of surfaces.

A simple screw mounting, *a*, uses a high-expansion brass sleeve to offset the low expansion of carbide. Within the temperature range where expansion of all three materials is linear, no real change of screw tension will take place provided temperature is uniform throughout the assembly.

In the equation for determining dimensions, ϵ = coefficient of linear thermal expansion, in. per in. per deg F (or deg C), with subscripts *s*, *c* and *b* denoting steel, carbide and brass, respectively; lengths are in inches.

Conical mounting surfaces with a common apex, *b*, maintain concentricity through a temperature range. Stress is limited to the frictional drag at the interface of the two materials.

How to determine circulating power in controlled

Epicyclic Gear Systems

By H. G. Laughlin, A. R. Holowenko and A. S. Hall

POWER transmission systems of the mechanical "differential" type can be adapted to a wide range of both constant and variable-speed drive requirements. Potential applications include speed-control, as well as speed-changing, equipment.

Basically, these systems consist of three rotating elements; the speed of any one element being a function of the speeds of the other two. This general arrangement is exemplified by an epicyclic gear system, *Fig.* 1*a*, in which the speed of one of the rotating elements is controlled by means of a fixed or variable-speed gear train connected to either of the other two elements.

In application, these systems will usually provide a compact and rugged drive assembly but are subject to certain design limitations. One inherent feature of an epicyclic gear system containing a control circuit, and one that may be easily overlooked, is the circulating power load within the system. Depending upon the design of the system, the amount of circulating power may either be a fraction of, or many times greater than, the input power. This characteristic thus becomes an important design factor to be considered along with the primary functions of the overall equipment.

Due to the rather complex kinematic arrangement of most epicyclic systems, velocity, force, torque, and energy relationships between the various elements are often difficult to visualize. This condition is especially true with regard to the amount of circulating power. If this latter feature is neglected or overlooked as a design factor, low overall efficiency of the equipment may result.

In this article, general design equations are developed for determination of the amount of circulating power as a function of the input power. Expressions for this function are also established in terms of defined velocity ratios across the entire system and across the control circuit. Use of this approach eliminates trial-and-error design procedures in predicting circulating power loads and provides a useful tool for analyzing the application possibilities and limitations of different epicyclic gear systems.

Basic Concepts: A specific example of a typical epicyclic gear system containing a branch control circuit is shown in *Fig.* 1*a*. The branch control circuit, which controls the speed of element 2, is the gear train *N-K-E-D*, across elements 1 and 2.

This epicyclic gear system, *Fig.* 1*a*, can be reduced to a simple schematic arrangement, as shown in *Fig.* 1*b*. In fact, all epicyclic systems of this general type can be simplified in the same fashion.

In *Fig.* 1*b*, the differential unit, which is represented by a rectangular box, has three rotating elements (1, 2 and 3) projecting from the box. One of these elements is always an arm which carries the planetary gears, while the other two elements are rotating gears on independent axes.

For the specific arrangement shown in *Fig.* 1, the arm is represented by element 1 and the an-

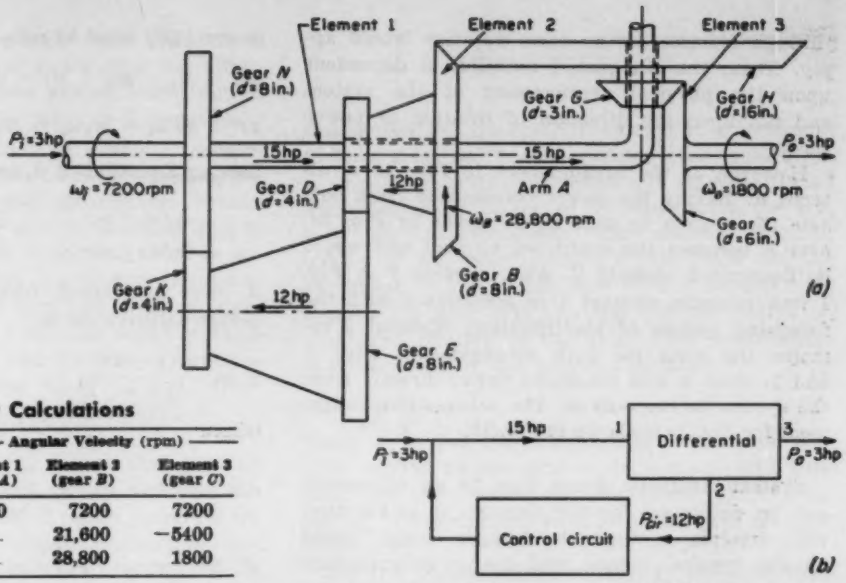


Fig. 1 — Typical controlled epicyclic gear system showing, *a*, arrangement of elements and, *b*, simplified schematic diagram for analysis of power flow. An efficiency of 100 per cent is assumed

Table 1—Velocity Calculations

	Angular Velocity (rpm)		
	Element 1 (arm *A*)	Element 2 (gear *B*)	Element 3 (gear *C*)
ω_a (arm)	7200	7200	7200
ω_{ga} (gear to arm)	....	21,600	−5400
ω_g (gear)	....	28,800	1800

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gular velocity of gear *B* is controlled by a branch control circuit consisting of a gear train connecting elements 1 and 2. Rotating element 3 transmits power directly from the system. Also, in this case, the circulating power flows from element 2 through the control circuit to element 1.

Since there are six possible schematic arrangements, depending upon which two elements are gears, which two elements are connected by the branch control circuit, and which two elements are selected for input and output, it is necessary that the exact notation of elements 1, 2, and 3 be well defined for use in the development which follows.

Thus, element 3 will always be that rotating element, projecting from the differential directly to outside the system, which has no connection with the control circuit. Sometimes, element 3 will be the arm; in other cases, it may be one of the two gears which project from the differential.

Rotating element 1 will always be that element, projecting from the differential to outside the system, that is connected to rotating element 2 by means of the branch control circuit, which may consist of either a fixed or variable-speed gear train. Rotating element 2 will always be that member which transmits power to or from the differential to the branch control circuit, but does not transmit power directly to or from the outside of the system.

For the system in *Fig.* 1, power is transmitted from the differential directly to outside the system by rotating element 3 which, in this case, is a gear (*C*). Power enters the system from the outside through arm, or shaft, *A* which therefore must be designated as element 1 since it is connected to rotating element 2 by the branch control circuit containing the fixed gear train, *N-K-E-D*.. Rotating element 2 is the controlled element and has no direct connection from the differential to outside the system.

This arrangement makes use of the epicyclic system as a speed reducer. Even if the flow of power through the system were reversed, with the input through element 3 and the output

Nomenclature

d = Pitch diameter of gear, in.
M = Torque transmitted, lb-in.
P = Power, hp
P_i, P_o = Input and output power, respectively, hp
P_{cir} = Circulating power in branch control circuit (Equation 1), hp
R = Velocity ratio, Equation 8
r = Velocity ratio, Equation 7
γ = Power ratio, Equation 2
ω = Angular speed, rpm
ω_a = Absolute angular velocity of gear arm, rpm
ω_g = Absolute angular velocity of gear, rpm
ω_{ga} = Angular velocity of gear relative to gear arm, rpm
ω_i, ω_o = Angular speeds of input and output members, respectively, rpm

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through element 1, the same notation would apply. Thus, the designated notation is dependent upon the physical arrangement of the system and not upon the direction of rotation or power flow.

However, if the arrangement in *Fig.* 1*a* is altered by having the power transmitted from outside the system to gear *D*, as shown in *Fig.* 2*a*, arm *A* becomes the controlled element and would be designated element 2. Also, element 2 in *Fig.* 1 now becomes element 1 in accordance with the foregoing system of identification. Element 3 remains the same for both arrangements, *Figs.* 1 and 2, since it still transmits power directly from the system to the outside. The schematic arrangement for *Fig.* 2*a* is shown in *Fig.* 2*b*.

System Analysis: From *Fig.* 1*b* an expression can be developed for the amount of power that will circulate through the branch circuit, based on the general torque and energy relationships between the three basic system elements.

First, circulating power will be defined here as the total power flowing through the branch control circuit. The ratio of the circulating power, P_{cir}, to the power, P_3, flowing through element 3 will be called γ.

By definition, using *Fig.* 1 as a reference,

$$P_{cir} = \gamma P_3 \quad \ldots\ldots (1)$$

and

$$\gamma = \frac{P_{cir}}{P_3} = \frac{M_2 \omega_2}{M_3 \omega_3} \quad \ldots\ldots (2)$$

where symbols are given in the *Nomenclature* and subscripts identify individual elements.

If the differential of *Fig.* 1 is considered as an isolated unit, the summation of torques (ΣM) and power (ΣP) must be zero. Thus,

$$\Sigma M = M_1 + M_2 + M_3 = 0 \quad \ldots\ldots (3)$$

$$\Sigma P = M_1 \omega_1 + M_2 \omega_2 + M_3 \omega_3 = 0 \quad \ldots\ldots (4)$$

Solving Equations 2, 3, and 4 simultaneously gives:

$$\gamma = \frac{\omega_2 (\omega_3 - \omega_1)}{\omega_3 (\omega_1 - \omega_2)} \quad \ldots\ldots (5)$$

A more convenient form of this expression for design calculations is:

$$\gamma = \frac{r (1 - R)}{1 - r} \quad \ldots\ldots (6)$$

where

$$r = \frac{\omega_2}{\omega_1} \quad \ldots\ldots (7)$$

$$R = \frac{\omega_1}{\omega_3} \quad \ldots\ldots (8)$$

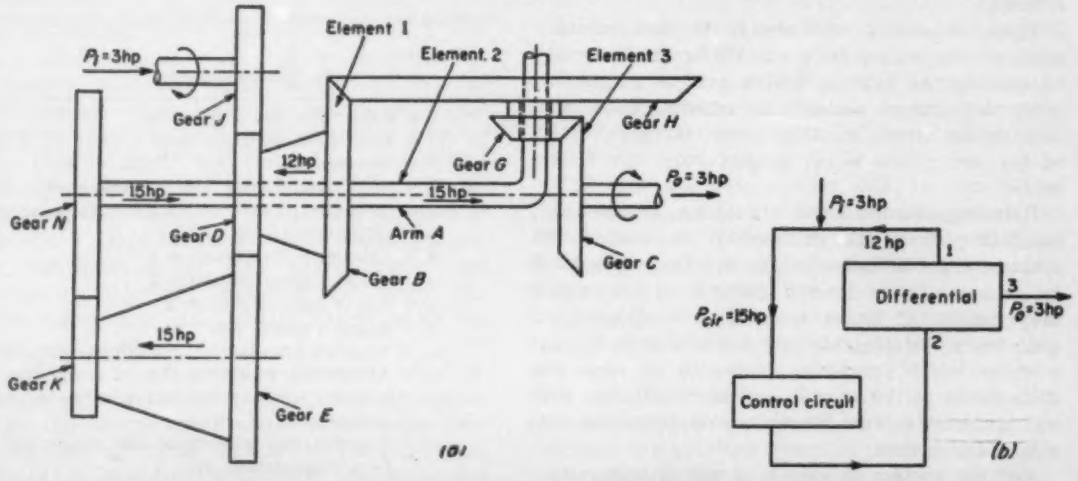
For the epicylic gear system shown in *Fig.* 1, ω_1 = 7200 rpm, ω_2 = 28,800 rpm and ω_3 = 1800 rpm. From Equation 7, r = 28,800/7200 = 4. This value is positive since ω_2 and ω_1 are in the same direction. From Equation 8, R = 7200/1800 = 4, and, from Equation 6,

$$\gamma = \frac{4 (1 - 4)}{1 - 4} = +4$$

The positive value of γ indicates that power is flowing from the differential through both elements 2 and 3. If power flows into the differential from element 2 and out through 3, γ will be negative. From Equation 1, P_{cir} = 4 (3) = 12 hp circulating through the branch control circuit.

In general, γ is positive if power flows into or

Fig. 2 — Modified epicyclic gear system obtained by altering the arrangement of power-transmitting elements in *Fig.* 1. System design is shown at *a*, simplified power-flow diagram at *b*



from the differential through both elements 2 and 3. However, if power flows into the differential through one of these elements and out of the differential through the other, γ is negative.

EXAMPLE PROBLEM: Another example, demonstrating the use of Equation 6 for determining the amount of circulating power through the branch circuit, is provided by the system shown in *Fig.* 3. Elements 1, 2, and 3 have been designated in accordance with the method previously discussed; $\omega_1 = 400$ rpm, $\omega_2 = 500$ rpm and $\omega_3 = 50$ rpm. From Equation 7, $r = -1.25$. The negative value indicates that elements 1 and 2 rotate in opposite directions. From Equation 8, $R = -8$; from Equation 6, $\gamma = -5$; and from Equation 1, $P_{cir} = -100$ hp.

The negative value of P_{cir} means that the 100 hp flows through the branch circuit and into the differential through element 2, since power flows out of the differential through element 3. Although only 20 hp is fed into the system, 100 hp actually flows through the branch circuit into element 2, and 80 hp flows from the differential through element 1 into the branch circuit.

The importance of Equation 6 as a design tool is readily apparent wherever it is necessary to design for a minimum, or specific, amount of circulating power in an epicyclic gear system.

The value of R is usually specified as a design requirement since it represents either the train value or transmission ratio of the system, depending upon the direction of power flow through the equipment. When R is assigned a constant value, the amount of circulating power can then be controlled by manipulating the value of r.

Velocity Calculations: Since R and r are defined functions of certain angular velocities of the various elements of the epicyclic system, it is necessary to have a method for determining these values.

Angular velocities of elements in epicyclic trains are most easily computed by considering the relative motions involved. The absolute angular motion of any gear in the epicyclic train may be expressed as the vector sum of the angular motion of the gear arm and the angular motion of that gear relative to the arm. This relationship is represented by the vectorial equation:

$$\omega_g = \omega_a + \omega_{ga} \quad \ldots\ldots (9)$$

where ω_g is the absolute angular velocity of any gear carried by the arm or in contact with this gear, ω_a is the absolute angular velocity of the arm, and ω_{ga} is the angular velocity of the gear relative to the arm.

For the system shown in *Fig.* 1, assuming that only the input angular velocity ($\omega_i = 7200$ rpm) is known, the absolute rpm of elements 2 and 3 can be easily determined from Equation 9 using the form shown in *Table* 1.

In this table, the absolute angular velocity of element 2 ($\omega_g = \omega_2$) was determined directly from the gear train ratio of the branch circuit. Thus, from *Fig.* 1*a*,

$$\omega_2 = 7200 \left(\frac{8}{4}\right)\left(\frac{8}{4}\right) = +28{,}800 \text{ rpm}$$

The positive value indicates that ω_2 and ω_1 have the same direction. The relative velocity of element 2 to element 1 ($\omega_{ga} = \omega_{21}$) is given by the difference of the absolute velocities of elements 2 and 1.

The relative velocity of element 3 with respect

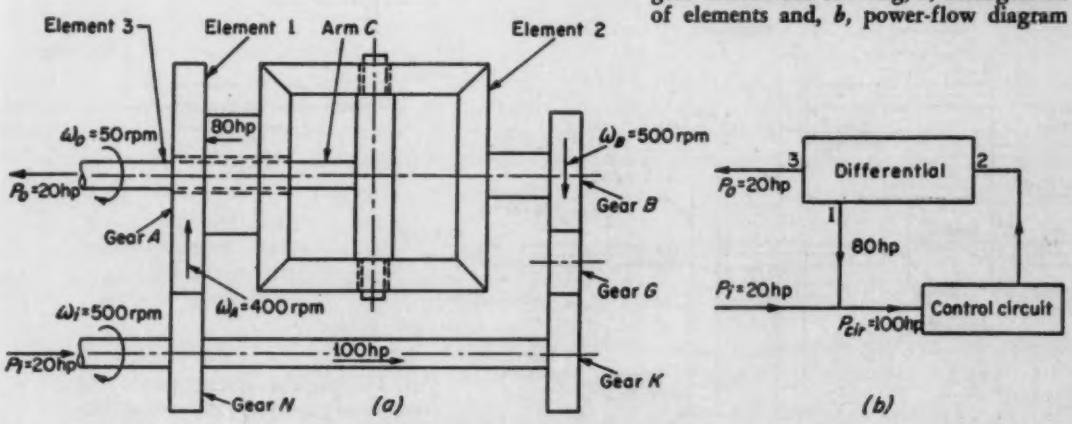


Fig. 3—Epicyclic gear system with bevel-gear differential showing, *a*, arrangement of elements and, *b*, power-flow diagram

to the arm ($\omega_{gs} = \omega_{31}$,) is determined by considering the arm as stationary while gear B (element 2) rotates at 21,600 rpm:

$$\omega_{31} = -21{,}600\left(\frac{8}{16}\right)\left(\frac{3}{6}\right) = -5400 \text{ rpm}$$

The negative value shows that the relative motion of gear C (element 3) with respect to the arm is opposite in direction to that of element 2. Thus,

$$\omega_3 = 7200 + (-5400) = +1800 \text{ rpm}$$

The positive sign again indicates that element 3 has the same direction of absolute motion as element 1, which was assumed to have a positive direction of rotation.

Complex System Example: A final example for demonstrating the use of both Equations 6 and 9 is provided by the system shown in *Fig.* 4. This arrangement is composed entirely of spur gears with the compound planetary gears, L and E, carried by arm A. For the gear sizes shown, the value of γ will be less than unity.

In *Fig.* 4, elements 1, 2 and 3 have been designated in the prescribed manner. It will be assumed that the angular velocity of element 1, which is the output member here, is known: $\omega_1 = \omega_o = 100$ rpm. For elements 2 and 3, angular velocities may be determined from Equation 9.

The velocity of element 2 can be determined directly by multiplying the velocity of element 1 by the fixed train ratio across the branch circuit.

$$\omega_2 = 100\left(\frac{30}{60}\right)\left(\frac{15}{75}\right) = +10 \text{ rpm}$$

Results of velocity calculations are given in *Table* 2. Relative velocity values, ω_{gs}, were determined as follows:

$$\omega_{21} = \omega_{BA} = 10 - 100 = -90 \text{ rpm}$$

$$\omega_{31} = \omega_{CA} = 90\left(\frac{100}{20}\right)\left(\frac{32}{20}\right)\left(\frac{20}{16}\right) = 900 \text{ rpm}$$

From Equation 9,

$$\omega_3 = \omega_C = 100 + 900 = 1000 \text{ rpm}$$

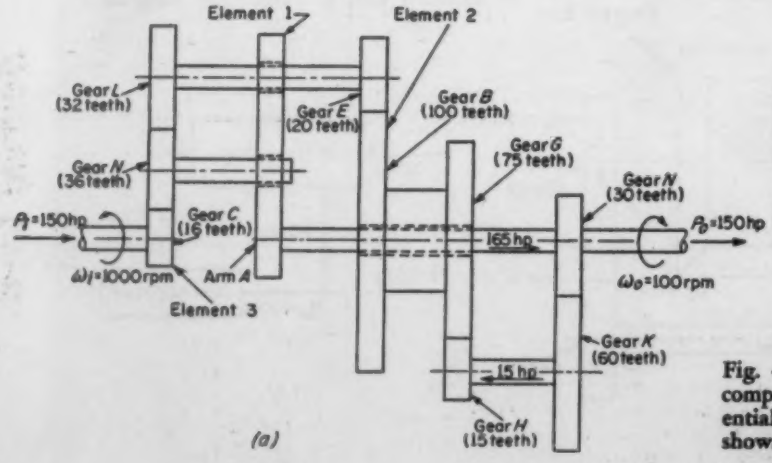
From Equations 7 and 8, $r = 0.1$ and $R = 0.1$. From Equation 6 then, $\gamma = 0.1$. Finally, from Equation 1, $P_{cir} = 150\ (0.1) = 15$ hp.

Thus, a circulating power of 15 hp flows through the branch circuit toward element 2 and into the differential. Power also flows from element 3 into the differential as shown schematically in *Fig.* 4*b*. As a result, the amount of power flowing from the differential through element 1 must be 165 hp.

A future article will consider design techniques for specific applications of epicyclic gear systems. Design charts and equations based on the methods developed in this article will be presented.

Table 2—Velocity Calculations

	Angular Velocity (rpm)		
	Element 1 (arm *A*)	Element 2 (gear *B*)	Element 3 (gear *C*)
ω_a (arm)	100	100	100
ω_{gs} (gear to arm)	...	−90	900
ω_g (gear)	...	10	1000



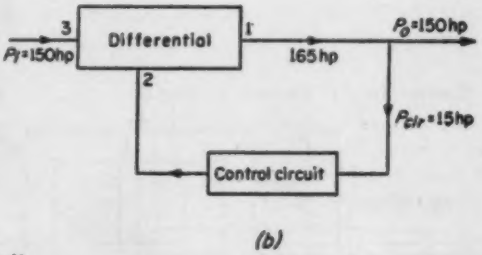


Fig. 4—Epicyclic system employing compound planetary gears for differential action. Drive assembly is shown at *a*, power-flow diagram at *b*

Nomograph helps find

V-Belt Drive Bearing Loads

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LOAD imposed on machine bearings by V-belt drives can be quickly estimated from the accompanying nomograph. The chart on the next page solves this fundamental equation relating power, belt tensions, speed and sheave diameter:

$$\frac{T_1 - T_2}{P} = \frac{126050}{DN} \quad \ldots\ldots (1)$$

where P = power transmitted, hp; T_1 = tight side tension, lb; T_2 = slack side tension, lb; D = pitch diameter of sheave, in.; and N = speed of the same sheave, rpm. The quantity $(T_1 - T_2)/P$ is the effective belt tension, lb per hp. For an actual drive, P is the rated horsepower of the motor or engine times the service factor. Service factors depend upon the characteristics of both prime mover and driven machine, and are tabulated in the engineering manuals published by V-belt and sheave manufacturers.

TOTAL BELT PULL: The load on the bearings is the result of combined pull of tight and slack sides of the belts. Most V-belt drives are set up so that $T_1/T_2 = 5$, approximately. This leads to the relation,

$$T_1 + T_2 = 1.5\,(T_1 - T_2) \quad \ldots\ldots (2)$$

BEARING LOAD DUE TO BELT PULL: With the sheave mounted on a two-bearing shaft, the load distribution between bearings depends on the relative locations of bearings and sheave. From *Fig.* 1, the bearing loads F_1 and F_2 are found by summation of forces and moments:

$$F_2 = \frac{x}{y}\,(T_1 + T_2) \quad \ldots\ldots (3)$$

$$F_1 = \left(\frac{x}{y} - 1\right)(T_1 + T_2) \quad \ldots\ldots (4)$$

These expressions show that the bearing closest to the center of belt pull is exposed to the greatest load. For electric motors in standard NEMA frame sizes, x/y generally is on the order of 1.3 to 1.4.

Combining Equations 2 and 3 and assigning to x/y the convenient value 1.33 gives the maximum bearing load due to belt pull in a V-belt drive as, approximately,

$$F_2 = 2(T_1 - T_2) \quad \ldots\ldots (5)$$

In the event the overhang $(x-y)$ is large compared with the bearing span (y), as might happen with an exceptionally wide sheave face, the factor x/y may be larger than 1.33. Then the constant in Equation 5 should be correspondingly larger than 2.

EXAMPLE: Calculate bearing load due to belt tension on a V-belt drive having a 10-in. pitch diameter sheave on a 100-hp, 1750-rpm motor. Driven sheave pitch diameter is 30 in. and the service factor for the drive is 1.2.

Solution: As shown on the nomograph, connect values 10.0 (D-scale) and 1750 (N-scale) with straight edge. Intersection with $(T_1 - T_2)/P$ scale reads 7.2. Actual effective belt pull for this

Fig. 1 — Load distribution between bearings of a shaft carrying a V-belt sheave

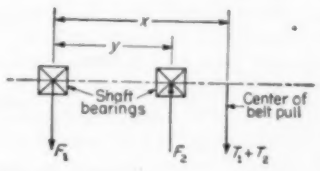
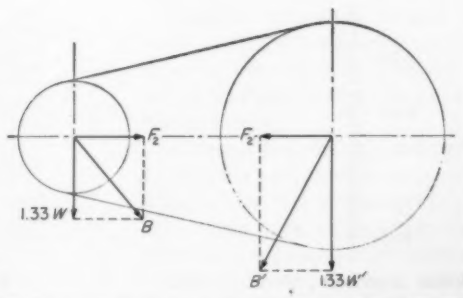


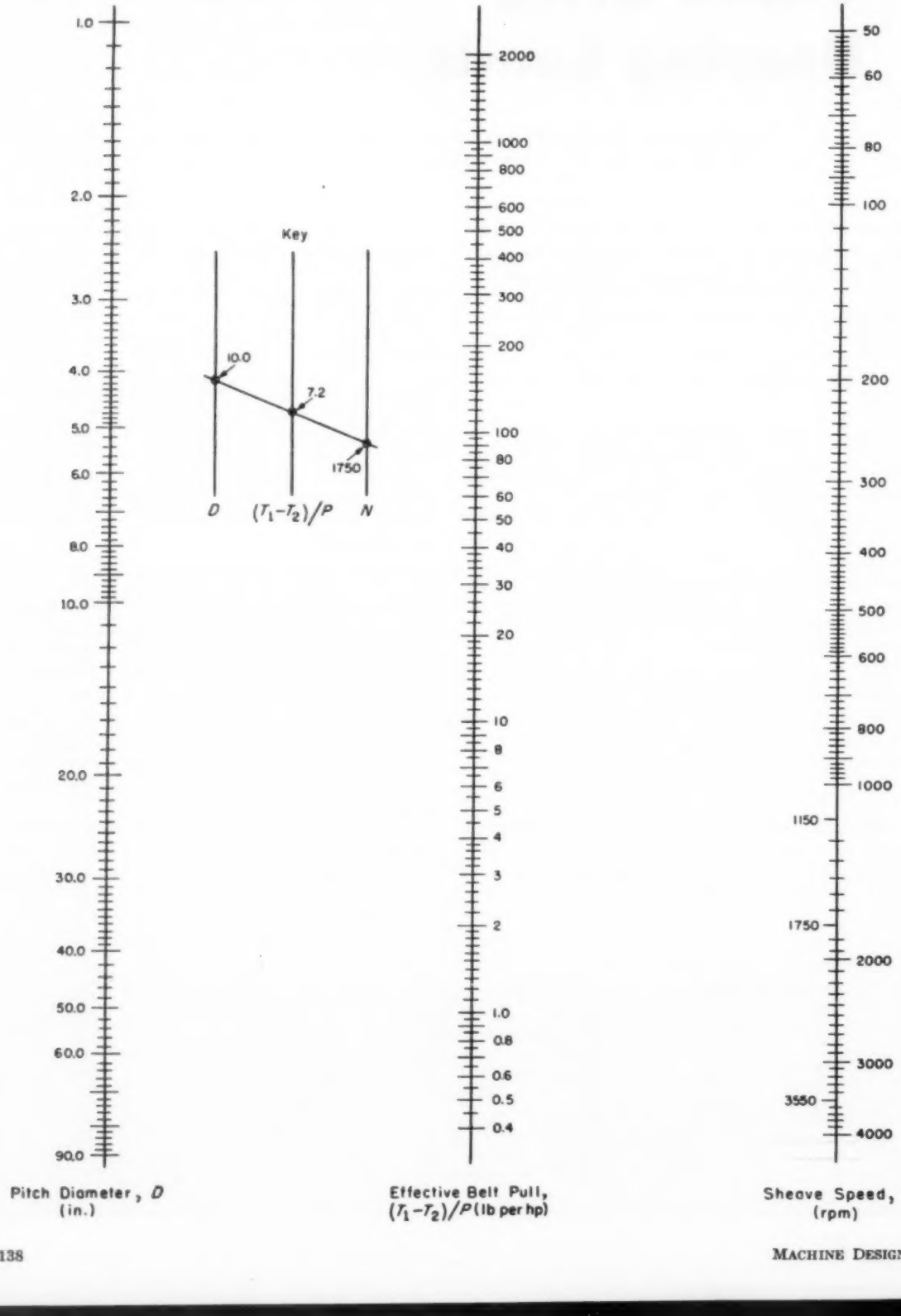
Fig. 2—Right—Total bearing loads B and B' resulting from combined belt pull and sheave weights W and W'. If x is greater than 1.33 y, *Fig.* 1, factors modifying W and W' should be adjusted in proportion



drive is (7.2) (100) (1.2) = 864 lb, and total bearing load due to belt pull, Equation 5, is (2) (864) = 1728 lb.

TOTAL BEARING LOAD: To the load from belt pull, Equation 5, must be added the bearing load due to the weight of the sheave. The graphical addition, taking into account both direction and magnitude, is illustrated in *Fig.* 2. The result is total bearing load due to the V-belt drive.

Load on the bearings due to rotor weights, etc., apart from the V-belt drive, can be added graphically in the same manner as shown in *Fig.* 2.



DESIGN ABSTRACTS

Unique properties and characteristics suggest applications for . . .

Ceramic Materials

By E. J. Smoke and J. H. Koenig

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CERAMIC products are defined as those made of inorganic minerals which are usually subjected to high temperatures during fabrication. This definition embraces a wide range of unique properties.

Refractory Properties: Among the unique properties of ceramic materials is refractoriness; that is, resistance to high temperature. *Table* 1 lists the melting temperatures of some ceramic materials along with those of several metals. Melting temperatures of the basic crystalline phases of most ceramic materials are quite high, starting in the range of 3000 F; iron melts at 2895 F.

Ceramics made of clinoenstatite, titania, silica, mullite, forsterite, alumina, spinel, zircon, beryllia, zirconia, magnesia and thoria are oxide-type ceramics. All but the first two are used as refractory materials where high-temperature processing is involved. Thoria has a very high melting point; however, it is radioactive. Silicon carbide is used as a refractory. Boron carbide has a high melting temperature, but it is used only in special cases. Other carbides, sulphides, nitrides, and borides have still higher melting temperatures but have only been made experimentally or on a very limited scale because of the rareness of some of the elements involved and the protective atmosphere necessary in using these materials.

Ceramic products are generally a mixture of one or more crystalline phases with glass, the latter material varying up to approximately 45 per cent. This glass content affects the refractory properties. *Table* 2 lists the safe continuous operating temperatures of some of these ceramics. The best glasses can be used continuously only up to approximately 900 F. Steatite and forsterite can be used continuously to 1800 F without distortion when used as technical ware such as high-frequency insulation, or whenever dimensional tolerances in the range of plus or minus 1 per cent are prerequisite. Normal porcelains have been used up to 2185 F. Zircon, whether used as technical ceramic or as a refractory, operates very well up to 2650 F. Silicon carbide stands up very well to approximately 1750 F in air. In protective atmospheres it can be used to higher temperatures. Some types are used as electrical heating elements because of their low electrical resistance. Silica is used principally as a refractory in open-hearth furnaces where the temperature approaches 3000 F. Mullite refractories are used continuously up to 3200 F.

Table 1—Melting Temperatures of Ceramic Materials

Material	Temperature (F)
Hafnium carbide	7520
Tantalum carbide	7025
Graphite	6870
Zirconium carbide	6370
Tungsten	6100
Tantalum nitride	6050
Titanium carbide	5660
Thoria	5630
Zirconium boride	5530
Titanium boride	5250
Magnesia	5072
Silicon carbide	4892
Zirconia	4850
Molybdenum	4748
Beryllia	4660
Zircon	4530
Boron carbide	4430
Silicon carbide (volatilizes)	4160
Spinel	3860
Alumina	3720
Magnesium sulphide	3460
Forsterite	3430
Mullite	3400
Platinum	3220
Silica	3038
Titania	2920
Iron	2995
Clinoenstatite	2835

The effect of glass content and/or an additional crystalline phase or phases is illustrated by the safe continuous operating temperatures of several alumina bodies. A body containing 86 per cent alumina can be used continuously up to 2550 F; another containing 96 per cent, up to 3050 F; while pure recrystallized alumina (that is, containing no glass) can be used continuously up to 3520 F. These are used for furnace parts and as technical ceramics of close dimensional tolerance and for high-temperature vacuum applications.

Zirconia provides a very high safe continuous operating temperature, about 4200 F, and in the fused, stabilized form is used for furnace parts.

Alumina and zirconia are applied to metals in thicknesses up to 0.010-in. by the flame-spray process. This type of coating shows promise for heat-engine parts, abrasion-resistant coatings and erosion-resistant parts.

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Hardness: High hardness is another property unique to ceramics covering the range from 30 on the Knoop scale for mineral gypsum to 7000 for diamond as given in *Table* 3. Glasses range from 300 to 500. One of the hardest metals is hardened steel at Rockwell 60.5 C which is approximately 750 on the Knoop scale. The majority of ceramics possess greater hardness. The cemented carbides are made of synthetic ceramic materials such as tungsten, titanium and tantalum carbides, whose Knoop hardness numbers range from 1400 to 1800.

Alumina has a Knoop hardness value of 2000. This extreme hardness and the fact that this ceramic can be fabricated to extremely close dimensional tolerance allow its use as wear-resistant parts such as gages, bearings, thread guides, nozzles and technical ware in general. It is volume stable with respect to time and temperature.

Silicon carbide, with a Knoop hardness of 2500, is one of the most important abrasives in terms of lapping and grinding, and as grinding wheels. It serves best for fabricating very hard, dense materials such as ceramics, including cemented carbides, cast and chilled iron and nonferrous metals.

Titanium boride has a value of 2720 and boron carbide of 2800; this latter was the hardest synthetic material until quite recently. However, in the past year man has made the first synthetic diamonds. Diamond is the hardest known material.

Thermal Conductivity: Ceramic products cover a wide range of thermal conductivity from near zero up to 125 Btu/hr/sq ft/ degree F/ft at 140 F as shown in *Table* 4. In the very low range of thermal conductivity a variety of thermal insulating materials are manufactured from mineral products such as asbestos, magnesia, diatomaceous silica, refractory clays, mineral and glass wools and synthetic fibers; these are used from below room temperature to above 3000 F for drier, oven and furnace liners and backings, pipe covering, and numerous other applications.

Ceramic products in general are characterized by low thermal conductivity, and approximately 98 per cent of all products manufactured have thermal conductivity values no higher than 5 Btu. This is due partially to the large per cent of pore space or voids which are present in some of these materials. As noted in the foregoing, magnesia is an excellent thermal insulator, yet *Table* 4 shows that it has a value of 27. The low value is for a very porous material while the latter value is for one containing no more than one per cent pore volume. Thus, all ceramics possessing thermal-conductivity values above 5 Btu are nonporous materials. Alumina ceramics have thermal conductivity values up to 10 Btu. One use for this material, partly because of this property, is for spark-plug insulators.

Thermal Expansion: Ceramic materials are manufactured which cover the range of linear thermal expansion from 0.5 to 13 $\times$ 10^{-6} in./in./degree C between room temperature and 700 C as shown in *Table* 5. Magnesia has the highest thermal expansion at 12.8. Low-carbon steels have values in the range of 15 over the same temperature range while copper is approximately 17.

One of the prime applications of a desired high thermal expansion in ceramics is in glass-to-metal and ceramic-to-metal seals for electron tubes and other vacuum-tight, strong, high-temperature seals. There are two types of seals. The compression type is exemplified by copper and forsterite or alumina, and Kovar and alumina. In this case a metal of higher thermal expansion surrounds the ceramic of lower thermal expansion which, when soldered to the metal, produces a strong vacuum-tight compression seal. The other type is the matched seal in which the thermal expansion of metal and ceramic is approximately the same. Glass-to-Kovar is a glass-to-metal seal of this type. The iron-nickel series of alloys cover a wide range of thermal expansion, and a thermal expansion match can be found for most ceramics, however, only over a limited temperature range.

Table 2—Safe Continuous Operating Temperatures

Material	Temperature (F)
Zirconia	4200
Alumina (100 per cent)	3540
Mullite	3200
Alumina (96 per cent)	3100
Silica	2950
Silicon carbide	2750
Zircon	2650
Alumina (84 per cent)	2550
Porcelain	2185
Steatite	1830
Forsterite	1830
Glasses	700 to 900

Table 3—Hardness of Ceramic Materials

Material	Hardness (Knoop)
Diamond	7000
Boron carbide	2800
Titanium boride, 31 per cent, and boron carbide, 69 per cent (by weight)	2750
Titanium boride	2720
Silicon carbide	2500
Titanium carbide	2460
Zirconium carbide	2090
Alumina	2000
Tungsten carbide	1880
Cemented carbide	1400 to 1800
Zirconium boride	1560
Carboloy	1050 to 1500
Berylilia	1220
Quartz	800
Hardened steel (60.5 Rockwell C)	740
Glasses	300 to 500
Calcite	130
Gypsum	30

Table 4—Thermal Conductivity of Ceramic Materials

Material	Thermal Conductivity* (Btu/hr/sq ft/deg F/ft)
Copper	218
Berylilia	125
Aluminum	118
Berylilia porcelain	30 to 90
Magnesia	27
Lead	19
Tin oxide	17
Alumina	10
Classical ceramics	0.5 to 5
Thermal insulation	0.03 to 0.5

*At 140 F.

Invar is a low-expanding material at relatively low temperatures but expansion rate tends to increase quite rapidly as the temperature is increased. In the realm of ceramics, much lower thermal expansions are possible. In fact there are two types which actually

contract on heating. Both are lithium aluminosilicates. One type exhibiting low positive to low negative values, *Table* 5, is the crystalline phase beta-spodumene. It can be made to have no contraction or expansion up to 600 C. Beta-eucryptite is the other crystalline phase and its coefficient of linear thermal expansion is -5.6×10^{-6}. This latter material has not been made in the nonporous state and because of its very high degree of contraction, has found little use. However, the beta-spodumene is quite important as a refractory material (to 2200 F) of high thermal shock resistance.

Thermal shock resistance is relatively high in most porous ceramics because of inherent structure. However, where strong ceramics are desired, porosity must be minimized. In dense ceramics the thermal shock resistance is dependent to a marked degree on thermal expansion; the lower the thermal expansion the higher the thermal shock resistance. Similar specimens of an alumina ceramic whose coefficient of linear thermal expansion is 8.0, crack when quenched into water at room temperature from 400 F. Beta-spodumene bodies, whose thermal expansion approaches zero, have resisted failure when quenched from 2200 F in water at room temperature.

Strength: The compressive strength of ceramic materials covers a very wide range from materials so weak that they can be crushed between the fingers in the case of some heat insulators, to values as high as 600,000 psi for a mixture of 31 per cent (by weight) titanium boride and 69 per cent boron carbide. In general for more or less conventional ceramics, transverse strength is approximately 2 times and compressive strength varies from 8 to 10 times the tensile strength. One commercial alumina body has a tensile strength of 27,000 psi, its transverse strength is 50,000 psi, while its compressive strength is 290,000 psi. Alumina bodies with compressive strengths as high as 400,000 psi have been reported.

The values given in *Table* 6 are optimum values, and these tend to decrease either with a decrease in the basic crystalline phase or with increase in pore volume. As an illustration, alumina ceramics are manufactured as special refractories with compressive strengths of the order of 11,000 psi while that of the completely nonporous material used as wear-resistant parts and electrical insulation has a compressive strength of 290,000 psi. This extremely strong material is being used as extrusion and pressing die parts, precision gages, plungers for reciprocating pumps, mechanical seal parts, bearing sleeves, liners for pumps and impeller wear parts, thread guides, and as high-frequency insulation, particularly for vacuum-tight ceramic-to-metal seals.

Table 5—Coefficients of Linear Thermal Expansion

Material	Coefficient of Expansion* (10^{-6} in./in./degree C)
Steel	15
Magnesia	12.8
Forsterite	10.6
Kovar	9.2
Beryllia	8.4
Alumina	8.0
Steatite	7.8
Spinel	6.6
Porcelain	6.0
Wollastonite	5.9
Zircon	4.6
Zirconium boride	4.0
Chromium boride	4.0
Cordierite	2.3
Fused silica	0.55
Spodumene	−0.04 to +0.5
Eucryptite	−5.6

*Between room temperature and 700 C (1292 F).

Table 6—Tensile, Transverse and Compressive Strengths of Ceramic Materials

Material	Strengths Tensile (1000 psi)	Transverse (1000 psi)	Compressive (1000 psi)
Titanium boride, 31 per cent, and boron carbide, 69 per cent (by weight)	..	90	600
Alumina	27	50	280
Beryllia	..	34	225
Steatite	10	20	90
Forsterite	10	20	85
Zircon	13	24	75
Porcelain	6	11	50
Glass-bonded mica	7	15	35
Cordierite	5	16	35
Classical ceramics	..	..	35 or less

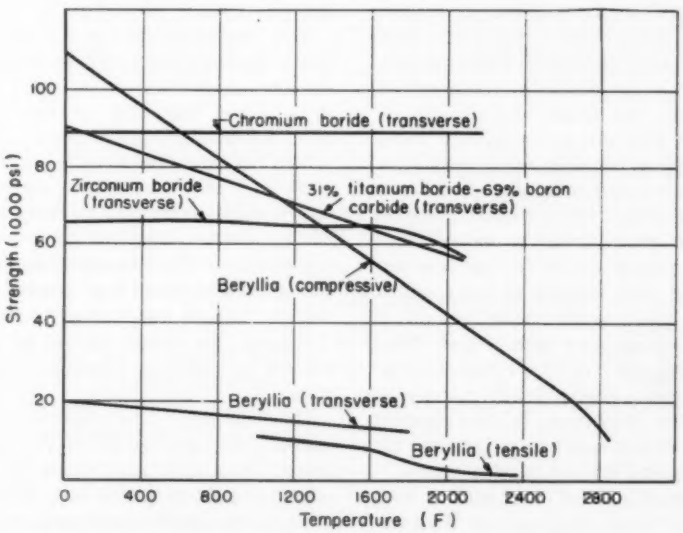

Fig. 1—Effect of temperature on strength of ceramic materials

DESIGN ABSTRACT

Beryllia is another extremely strong ceramic with a compressive strength of 188,000 psi and transverse strength of 35,000 psi. Steatite, forsterite and zircon ceramics have compressive-strength values between 75,000 and 90,000 psi. Steatite is the most economical of the group to manufacture. It is used very extensively as electrical insulation, especially for high-frequency applications, and at moderately elevated temperatures because of its high strength, excellent electrical insulating properties, and the ability to be fabricated to close dimensional tolerance. Porcelain, glass-bonded mica and cordierite have lower compressive strengths in the range of 35,000 to 50,000 psi. Porcelain, because of its strength, ease of manufacture and general durability, is used extensively for domestic and technical ceramics.

Effect of temperature on the strength of some ceramic materials is shown in *Fig.* 1. A beryllia ceramic, whose tensile strength is approximately 14,000 psi at room temperature, is still 5000 psi at 1800 F; its transverse strength at room temperature is 20,000 psi and still 11,500 psi at 1800 F; while its compressive strength at the lower temperature is 110,000 psi, 50,000 psi at 1800 F and 7000 psi at 2912 F. Chromium boride, whose room-temperature transverse strength is 88,000 psi, remains constant to 1700 F. Zirconium boride exhibits the same effect over the same temperature range with a value of 66,000 psi, and at 2200 F this value drops only to 55,000 psi.

From a paper entitled "Industrial Application of Ceramics" presented at the ASME Annual Meeting in Chicago, November 1955.

Design considerations for

Planet Pinions

By Walter B. Herndon

Detroit Transmission Div.
General Motors Corp.
Detroit

THE pinion is the most important member in a planetary gear set. It is loaded on both sides of its teeth under both drive and coast conditions. In a three-pinion planetary gear set there are six pitch points which are the only possible sources of noise and tooth failure. While a set of pinion gears makes contact at all six pitch points, the internal gear as well as the sun gear are each concerned with only three of these points, *Fig.* 1. A precisely made set of pinions will allow the use of internal and sun gears having wider tolerances on lead, lead variations, involute, and involute variations.

The planet carrier must keep the pinion gears properly spaced on a circle concentric with the base circles of the internal and sun gears. Also, the carrier must provide a good bearing for each pinion. This bearing must be in a common plane with the carrier axis and parallel to it. Any deviation in this respect will initiate lead errors between the pinion and its two mating gears.

Importance of the pinion bore cannot be overemphasized. An oversized bore will produce a condition similar to off-spacing of the pinion. A bore 0.0005-in. oversized will allow the pinion to float on a center 0.00025-in. ahead of the loaded pinions. An oversized or tapered bore will also permit the pinion to tilt. End thrust on the pinion resulting from contact with the internal gear is theoretically equal and opposite to that exerted from contact with the sun gear. However, due to variations from the theoretical, a certain amount of end thrust is usually present.

The pinion blank, as a rule, is much simpler than the ones used for the internal gear or the sun gear. It is basically an external gear with a precision bore. The pinion seldom requires a spline, bushing, or any other element which might complicate arbors and cause undue eccentricity, off-squareness, or complications in manufacture. For this reason, it seems that of the three gears in a planet, the pinion should be the easiest to make to precision tolerances.

To determine the required lead and involute modifications it is necessary to make a gear action layout about ten times actual size, *Fig.* 2. This layout shows both lead action and involute action. Theoretically, perfect leads and involutes together with rigid mountings result in smooth mesh with neither angular acceleration nor deceleration when the teeth are entering or leaving mesh. Lead or involute interference on entering or leaving mesh can cause serious difficulty. Such interference in a gear set results in noise, shock loading, excessive wear, pitting and sometimes tooth breakage.

In general, gear tooth form is modified from the theoretical to obtain long life and quiet operation. This is done on the gear tooth layout and checked by testing experimental pieces.

Metallurgical Considerations: Planet pinions in the Hydra-Matic automatic transmission are manufactured from two types of steel —SAE 5140-H and SAE 5145-H. The reason for using two types of steel is to control the hardenability of the varying section sizes of the pinions to result in optimum gear life.

Grain size of the "as received" material is specified to be "five" or 5-8 McQuaid-Ehn grain size specification chart.

The "as received" material specifications of the stock require that it have a controlled microstructure consisting of a uniform blocky structure of fairly open lamellar pearlite and blocky ferrite with some fine unreasolvable pearlite. This structure has been determined to be the most satisfactory for the different machining operations performed. With this structure a hardness limit range of Brinell hardness number 187-207 is specified.

The planet pinion gears are heat-

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treated. Specifications call for a fine Rockwell C hardness of 50-56 and a case depth of 0.005 to 0.010-in.

After the pinion gears have been austenitized and the proper case depth acquired, they are quenched in hot oil. A hot oil quench method was established on the basis of distortion of the tooth form and the inside diameter of the pinion gear. The hold-in-quench and slow-cool procedure can be classified as modified marquench process. The gears are then tempered to produce the required final hardness and to relieve quenching stresses.

A final hardness of Rockwell C 50-56 and a hardness check requirement of Superficial Rockwell hardness 15N scale 89-92 are specified to insure a good surface hardness from the added case.

Manufacturing: Blanks are cut in automatic screw machines. Precision boring and facing machines are used to bore, face, and chamfer the hole in the blank. The bore must be held to a 0.0003-in. tolerance and the face must be held square to the bore within 0.002-in. accuracy. The finish on the face must be held to 50 microinches maximum, and the finish on the bore also must be held within 50 microinches to permit gaging of the parts with an air gage.

The next operation on the blanks is to grind the unfinished face on rotary surface grinders. The machine must hold the ground face to within 50 microinches for finish and parallel to the turned face within 0.0005-in.

Following a hobbing operation the gears are shaved by rotary diagonal underpass shaving machines.

After heat treatment, the pinions are loaded into a semiautomatic machine that chamfers both sides of the gear teeth and grinds oil grooves on both thrust faces of the pinion.

The final machining operation is to hone the bore to size within 0.0005-in. with a finish of 10 to 12 microinches. Bore finish is important because it affects pinion life. Shock loads on a gear having a rough bore finish will cause excessive tilt and needle bearing wear would shorten the life of the pinion.

From "The Manufacture of Planet Pinions" in General Motors Engineering Journal, *November-December,* 1955.

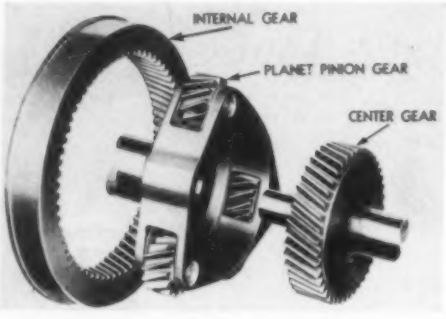


Fig. 1—Exploded view of planetary gear set

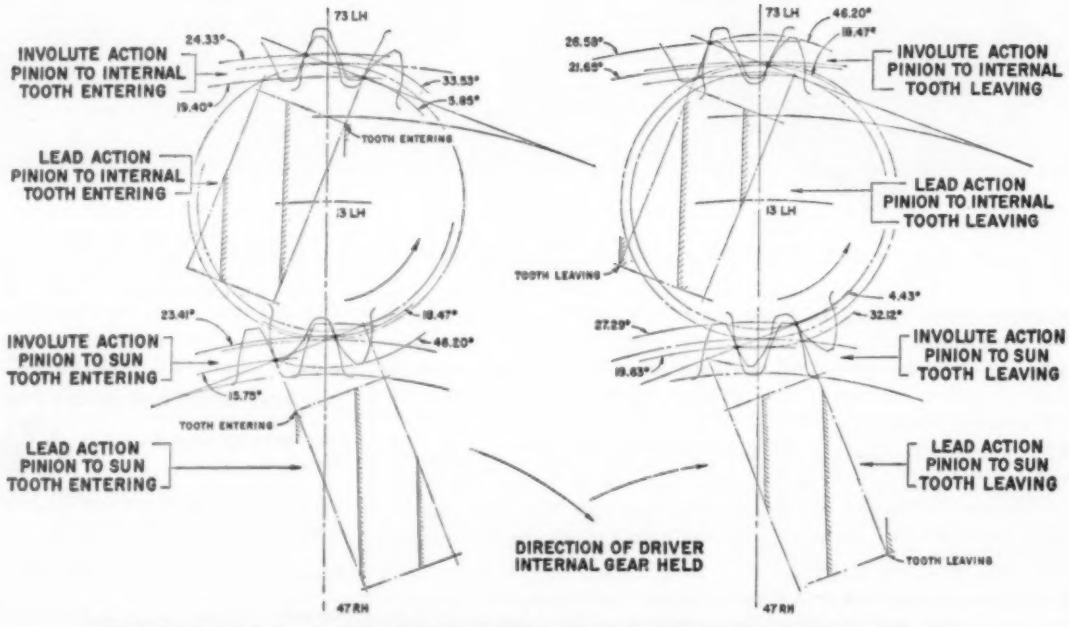
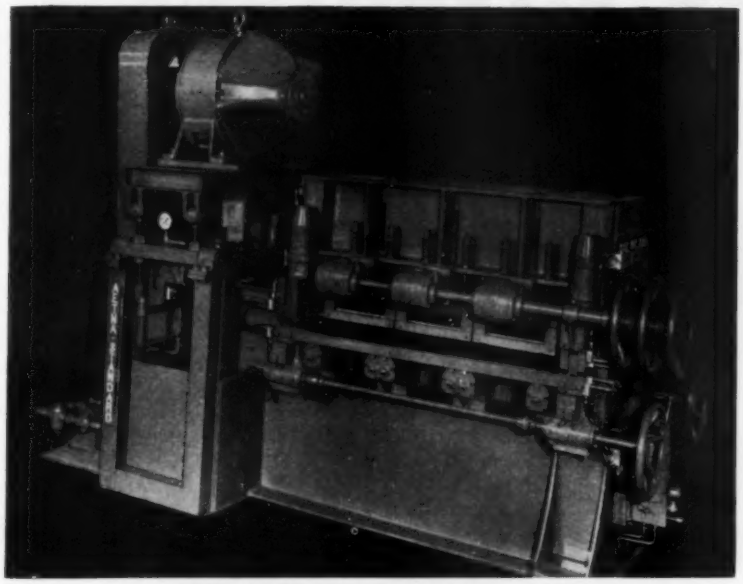


Fig. 2—Gear action layout showing bearing path of each tooth against its mate on the meshing gear as the tooth enters and leaves mesh. Points on this path are usually designated by degrees roll

BEARING TIPS by McGill



138 GUIDEROL® BEARINGS BACK UP WORK ROLLS IN AETNA STANDARD LEVELER

High load capacity vital to back-up roll support

For processing 16 to 30 gauge steel sheets and coils, this Roller Leveler built by Aetna Standard Engineering Company requires dependable components to deliver a consistent maximum output at speeds up to 400 feet a minute.

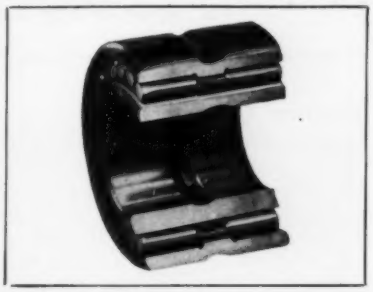
McGill GUIDEROL GR-16 bearings were selected for this machine and several larger versions use GR-24 and GR-36 bearings. They can carry the heavy irregular loads associated with flattening and leveling steel sheets and strips. Requiring less radial space, Guiderol bearings provide maximum roll neck diameters and offer greater strength at the necks of larger back-up rollers.

On the machine shown above, there is a total of 36 back-up rollers in 3 upper banks and 33 in 3 lower banks to resist the heavy pressure of the 48 inch working rolls. With a GUIDEROL bearing at each end of the 1¾" back-up rolls, a total of 138 bearings is required for the Leveler. These bearings have proved especially suited to supporting heavy loads longer in small radial space with reduced maintenance and production down time — important in steel mill operations.

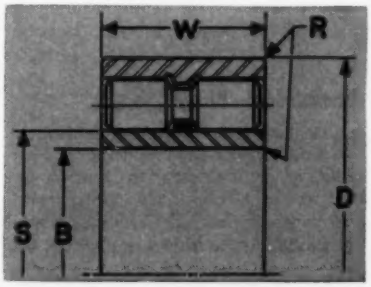
American Hoist Uses CT Series In Crane Blocks

Crane Blocks built by American Hoist and Derrick to withstand the greater strains and rough usage of lifts up to 500 tons rely on the greater capacity of GUIDEROL CT Series bearings in the sheaves. Interchangeable with retainer type cylindrical roller bearings, the CT Series full type roller construction has added capacity of over 38%. In sheaves these bearings offer greater angular stability with full race width rollers. Center guiding without retainer keeps these rollers aligned and prevents binding under eccentric loads.

Center-Guided Rollers Eliminate Load Wasting Cages



Guiderol Bearings inherently possess exceptionally high radial load capacity due to their full complement of small diameter rollers. Grooved rollers and a center guide rail keep rollers aligned as insurance against skewing and binding that is possible with ordinary needle bearings. Sizes interchange with needle and cylindrical roller bearings.



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HELPFUL LITERATURE
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Electrical Connectors

Miniature AN-type electrical connectors with one-piece molded inserts are described and illustrated in catalog. Series 1300 units are made in 3, 4 and 5-contact and 15, 19, 27 and 31-contact shell sizes. Electrical and mechanical specifications are presented. 4 pages. DeJur-Amsco Corp.

—Circle ITEM 1

Central Lubrication

Advantages of Farval centralized lubrication of various types of machines are expounded in illustrated bulletin No. 26-R. Operation of Dualine measuring valve is diagrammed in color and other components are shown. Variety of applications are pictured. 20 pages. Farval Corp.

—Circle ITEM 2

Mechanical Pump Seals

One piece assembly, presetting at the factory, collet type drive and circulating connections in glands are features of Mechanipak Unitary seals for process pumps. Cutaway views, recommended services and parts and their functions are detailed in illustrated booklet AD-151. 12 pages. Garlock Packing Co.

—Circle ITEM 3

Sheet Metal Fabrication

Typical sheet metal fabrications this company's Fabrication Div. can make are illustrated on this sheet. 2 pages. Industrial Equipment Co.

—Circle ITEM 4

Ball Valve

Change of shut-off direction, change of seat material and quick cleaning are possible without removing the Rockwell top entry ball valve from the line. It is rated at 300 psi on water, oil and gas and 400 psi on LP gas. Specifications are given in illustrated bulletin. 4 pages. Rockwood Sprinkler Co.

—Circle ITEM 5

Electric Heat Elements

Electronic and mechanical equipment can be operated at low temperatures when heated with Electro-Flex electrical heating elements. Flexible units can perform continuously at 450° F and can be made to order. Data on standard types and other uses are given. 4 pages. Electro-Flex Heat Inc.

—Circle ITEM 6

Hose Assemblies

Coupled hydraulic hose assemblies and fittings, available in wide variety of types, sizes and ratings, are detailed in illustrated bulletin 55S. Included are pressed-on, split flange, Duloc reusable, clamp and other types of assemblies. 8 pages. Anchor Coupling Co.

—Circle ITEM 7

Hydraulic Pneumatic Valves

Bulletin 155 on "Hydraulic Pneumatic Components" covers standard line of selector, restrictor, sequence, check and shut-off valves, both solenoid and manually operated. Special components for aircraft and general industrial use are also described. 34 pages. Aircraft Products Co.

—Circle ITEM 8

Drive Squares

Release No. 5512A entitled "Flexible Shaft Ideas for Engineers" suggests using integral formed drive squares in place of separate end fittings. Advantages of drive squares are pointed up and dimensions of available drive squares and mating parts are tabulated. 2 pages. S. S. White Industrial Div.

—Circle ITEM 9

Electrical Fittings

Descriptive and price information on solderless fittings and electrical hardware products is provided in catalog 561. Application data on pres-SURE-products covers splice caps, vinyl insulators, nylon insulators, terminal lugs and the C-24 pres-SURE-tool. Specifications are given. 4 pages. Buchanan Electrical Products Corp.

—Circle ITEM 10

Company Facilities

Well illustrated brochure serves to acquaint reader with this company's facilities and plant capacity. Firm produces building products, structural steel supplies, weldments, custom-built equipment, steel deck, roofing, conveying and processing equipment, wire mesh, reinforcing steel and many other products. 32 pages. Paul Mueller Co.

—Circle ITEM 11

Stationary Tachometers

New circuits and new takeoff heads that increase life by five times are featured by line of stationary tachometers described in bulletin 105. Typical speed measuring applications are pictured. 4 pages. Metron Instrument Co.

—Circle ITEM 12

Governor

Interchangeable weight systems for various requirements are feature of model 300 governor, subject of illustrated folder. It has cam nose, hinge and laminated weight systems and is offered with levers for constant speed or long range governing. 4 pages. Pierce Governor Co.

—Circle ITEM 13

Variable Speed Drive

One spring loaded and one manually operated pulley comprise the Lovejoy compound drive for ½ or ¾-hp 1750 rpm motors. Described in illustrated data sheet, it has an 8-to-1 speed ratio and uses handwheel control or yoke attachment. 2 pages. Lovejoy Flexible Coupling Co.

—Circle ITEM 14

Bevel Gear Machinery

Bevel gear machinery described in bulletin SD-3022E includes bevel and hypoid gear machines testing and lapping equipment, heat treating equipment and Curvic coupling grinders. Work ranges are listed. 8 pages. Gleason Works.

—Circle ITEM 15

Drafting Template

Full line of Kaylock miniature all metal, self-locking nuts is found on this drafting template, offered free. All configurations, all sizes of anchor nuts, including standard hex nuts and gang channel, are covered. Kaynar Co., Kaylock Div.

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Nonmetallic Materials

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—ITEM 221—

Helpful Literature

erties and characteristics, is described in bulletin "Polypenco Non-Metallics." Materials are offered on rod, strip, tubular bar, slab, flexible tubing, tape and plate shapes for machining into final form. 4 pages. Polymer Corp.

—Circle ITEM 17

Small Motors

Line of shaded-pole alternating current motors for use in vending machines, appliances, office machines, industrial instruments, servomechanisms and other applications are described in catalog F 4271-6. Ratings range up to 1/20 hp. 8-pages. Barber-Colman Co., Small Motors Div.

—Circle ITEM 18

Fabricated Plastic Products

Polyethylene and polyvinyl chloride fabricated products, plates, sheets, rods, tube, pipes and fittings and hot gas welding and spraying equipment are described and illustrated in general catalog. Chart shows chemical resistance of various products. 48 pages. American Agile Corp.

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Air & Hylraulic Cylinders

Wide variety of mountings is available in line of cylinders for 150-psi air and 300-psi oil hydraulic service. Detailed in illustrated catalog 701 are construction features, specifications and accessories of 300 series cylinders. 32 pages. Hydraulic Press Mfg. Co., Hydraulic Power Div.

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DC Contactors

Ratings from 25 to 100 amp, 600 v maximum, are available in type 522 heavy duty dc contactors, illustrated in descriptive bulletin 14B8171A. Single and double-pole units with normally open or normally closed contacts have mechanical interlocks and interchangeable parts. 8 pages. Allis-Chalmers Mfg. Co.

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Centralized Lubrication

How Trabon oil and grease systems cut costs on bearing lubrication is outlined in Trabon News Vol.-No. 1. Systems are designed for applications involving heat and vibration. Publication will be sent regularly upon request. 4-pages. Trabon Engineering Corp.

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Filtration Manual

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—ITEM 222—

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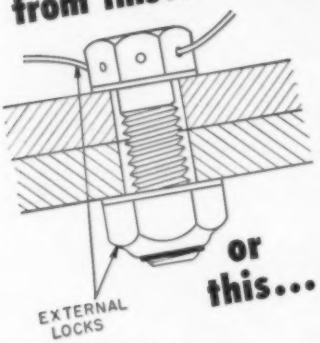

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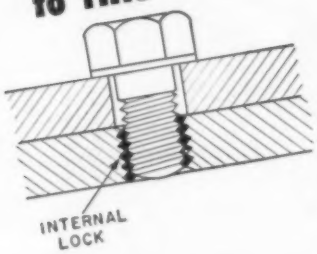

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123 SHELTER ROCK LANE, DANBURY, CONN.

☐ NEW—Design manual available on regular *Heli-Coil* Screw Thread Inserts.
☐ RUSH complete design data on *Heli-Coil* Mid-Grip Screw-Lock Inserts.
☐ WIRE your nearest representative to phone me at_____
☐ Send me, FREE, *Heli-Coil*, your case history periodical.

Name_____Title_____

Company_____

Address_____

City_____Zone____State_____ SOSS

☐ Heli-Coil Corporation has an outstanding staff of Thread Fastening Engineers. If your company would be interested in a "Thread Problem Symposium" CHECK HERE.

IN CANADA: W. R. WATKINS CO. LTD., 41 Kipling Ave. S, Toronto 18, Ont.

—ITEM 223—

Helpful Literature

requirements and selection of filter elements. Glossary of terms is highlight. Purolator Products, Inc.

—Circle ITEM 23

Stainless Sheet & Strip

MicroRold stainless steel sheet and strip produced by continuous cold reduction is described as to types and usage in bulletin 55-A. Sheet is available 36 in. wide and in thicknesses from 0.005 to 0.109-in. Veri-Thin MicroRold strip is offered in thicknesses from 0.001 to 0.009-in. 16 pages. Washington Steel Corp.

—Circle ITEM 24

Copying Equipment

How Xerography works in the Glenn L. Martin Co. to produce multiple copies of engineering drawings, organization charts, process bulletin, military specification and manufacturing manuals is related in case history bulletin X-43. Model 1218 copying equipment is shown. 4 pages. Haloid Co.

—Circle ITEM 25

Fine Pitch Gears

Line of nylon, phenolic and helical gears in 48, 64, 72 and 96 pitches, available from stock, are described and illustrated in catalog No. 8. Specifications are also given for fine pitch racks, miter gear boxes, pulleys, vernier and dial sets. 24 pages. PIC Design Corp.

—Circle ITEM 26

Plastics & Silicone Rubber

Examples of present molded plastics applications are pictured in brochure "The Plastics Story." Automatic molding facilities are covered. "Fabricated Silicone Rubber Parts" booklet relates how such parts are made for industrial needs. Four classes of rubber compounds are outlined. General Electric Co., Plastics Dept.

—Circle ITEM 27

Speed Reducers

Specifications, service factors, rating tables, dimensional drawings and selection data are found in catalog 600. Principle of Heliocentric speed reducers is described. Ratios are up to 80:1 in single stage units, 6400:1 in two-stage units. 76 pages. Novo Pump & Engine Co., Universal Gear Div.

—Circle ITEM 28

Photoelectric Cell

The Kodak Ektron Detector, a unique photoelectric cell which uses the electrical properties of lead sulfide to detect radiation in the infra-

ANNOUNCING...

the Beryllium Copper ROLLPIN®

Strong . . . highly resistant to corrosion . . . nonmagnetic . . . extremely conductive

Now you can use Rollpin to cut assembly and maintenance costs in a whole new group of applications. A new line made of beryllium copper, one of the strongest of the copper base alloys, opens the door to a wide variety of uses where resistance to corrosive attack, good electrical properties and other unusual characteristics are required. These slotted tubular copper spring-pins can be used in assemblies that range from plumbing fixtures to electrical instruments, particularly in conjunction with other copper base alloy components.

Rollpin has already established its ability to replace taper pins, straight pins and set screws; to serve as a rivet, dowel, hinge pin, cotter pin or stop pin . . . eliminating special machining, tapping and the need for hole reaming or precision tolerances. Driven into a hole drilled to normal production standards, it locks securely in place, yet can be readily drifted out and reused whenever necessary.

Rollpin is available in beryllium copper from .062″-diameter to .250″-diameter, and in steel and stainless steel up to .500″-diameter.

ELASTIC STOP NUT (ESNA) **CORPORATION OF AMERICA**

Elastic Stop Nut Corporation of America
Dept. R35-34, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ Data on beryllium copper Rollpin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

—ITEM 224—

For More Information Circle Item Number on Yellow Card—page 19

XUM

NOW NEW COMPACT STEARNS MAGNETIC DISC BRAKES

for New Motor Sizes

Stearns magnetic disc brakes eliminate waste time by stopping electric motors instantly... speed output by holding unbalanced loads during machining, assembling, etc. Now Stearns magnetic brakes — choice of leading motor manufacturers — are built to fit rerated NEMA motor frames in 1/20 hp to 100 hp size range, AC or DC.

Motor Frame or Floor Mounting. New Stearns brakes are built to mount on NEMA frames 42-C, 48-C, 56-C, 66-C, 182, 184, 213-286 — and can be adapted to mount on NEMA C flange face motors in 364-404 frame sizes. Stearns-type motor mounting and floor mounting also available.

Wide Torque Range For Wide Variety of Jobs. Torque range from 6 lb in. to 7,500 lb ft. With this range you can match torque to load conditions, shaft speed, etc.

New Shorter Size. Permits installation in close quarters.

Easy Adjustment. No special tools required. Easy torque and wear adjustment. Long-lasting linings easily replaced.

An Enclosure For Every Need. Explosion-proof — dust and waterproof — standard. Vertical or horizontal.

A Maintenance Man's "Dream" Unit. Simple to install — easy to maintain. Can be completely disassembled and reassembled in a few minutes.

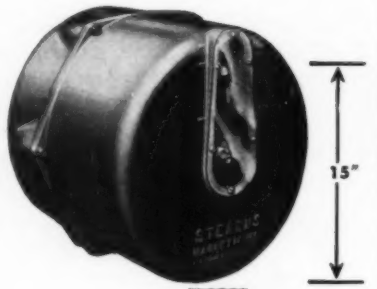
1118

H-40

H-50

H-70

H-1000



H-1200

Send For New Bulletin

Get complete details on new Stearns brakes. Write for brake portfolio 604-F-4.

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC., 692 S. 28th St., Milwaukee 46, Wis.

—ITEM 225—

Helpful Literature

red, visible and ultraviolet portions of the spectrum, is detailed in illustrated booklet. It has small size, mechanical ruggedness and high sensivity. Engineering and application data are cited. 24 pages. Eastman Kodak Co., Special Products Sales Div.

—Circle ITEM 29

Hydraulic Components

Descriptive data on Char-Lynn Hydraulic Horsepower Hi-Lo Power Pac, pumps, drive kits, supply tanks, Hold-Kontrol valve, control valve kits, hose coupler, filter and cylinders are found in catalog SDB05. Operating characteristics are given. 16 pages. Char-Lynn Co.

—Circle ITEM 30

Ventilated Clutch

With torque ratings from 27,000 to 900,000 in.-lb and horsepower ratings from 43 to 1430, line of Fawick VC Ventorque Clutches is suited for applications with high starting loads and sustained slippage. Bulletin ML-102-A has design features and specifications. 8 pages. Fawick Corp., Fawick Airfex Div.

—Circle ITEM 31

Phenolic Molding Compounds

Physical properties of Durez molding compounds are presented in brochure "Facts on Phenolics." Given are powder, molded material and electrical properties of general purpose, medium and high impact, electrical insulating and other materials. 16 pages. Hooker Electrochemical Co., Durez Plastics Div.

—Circle ITEM 32

Miniature Bearings

Radial, flanged, retainer, shielded, high speed, angular contact, pivot and thrust types of miniature ball bearings are covered by condensed catalog 1955-56-C. Basic dimensions and dynamic capacities are given for over 350 standard miniature ball bearings. 4 pages. Miniature Precision Bearings, Inc.

—Circle ITEM 33

Glass Fiber Products

Condensed data on the many products which comprise the L.O.F line of glass fiber products as well as application information are contained in illustrated catalog WPD-11. Types are available for heat control, sound absorption, vibration and shock control, electrical insulation and plastics reinforcement. 8 pages. L.O.F. Glass Fibers Co.

—Circle ITEM 34

TORRINGTON CUSTOM-MADE BEARINGS

"This Torrington design solves my bearing problem!"

Time and again, industrial firms with special bearing requirements turn their assignments over to Torrington—specialists in designing and building custom bearings.

This confidence has been won by years of successful experience. When you call on Torrington, you engage engineers who have devoted tens of thousands of hours to the design and construction of virtually every type of bearing. From their experience—and imagination—comes the *special* bearing that will bring you peak efficiency, service life and economy.

For a custom *or* standard bearing—any size, any type—you can rely on the skill and experience of Torrington.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866-1956

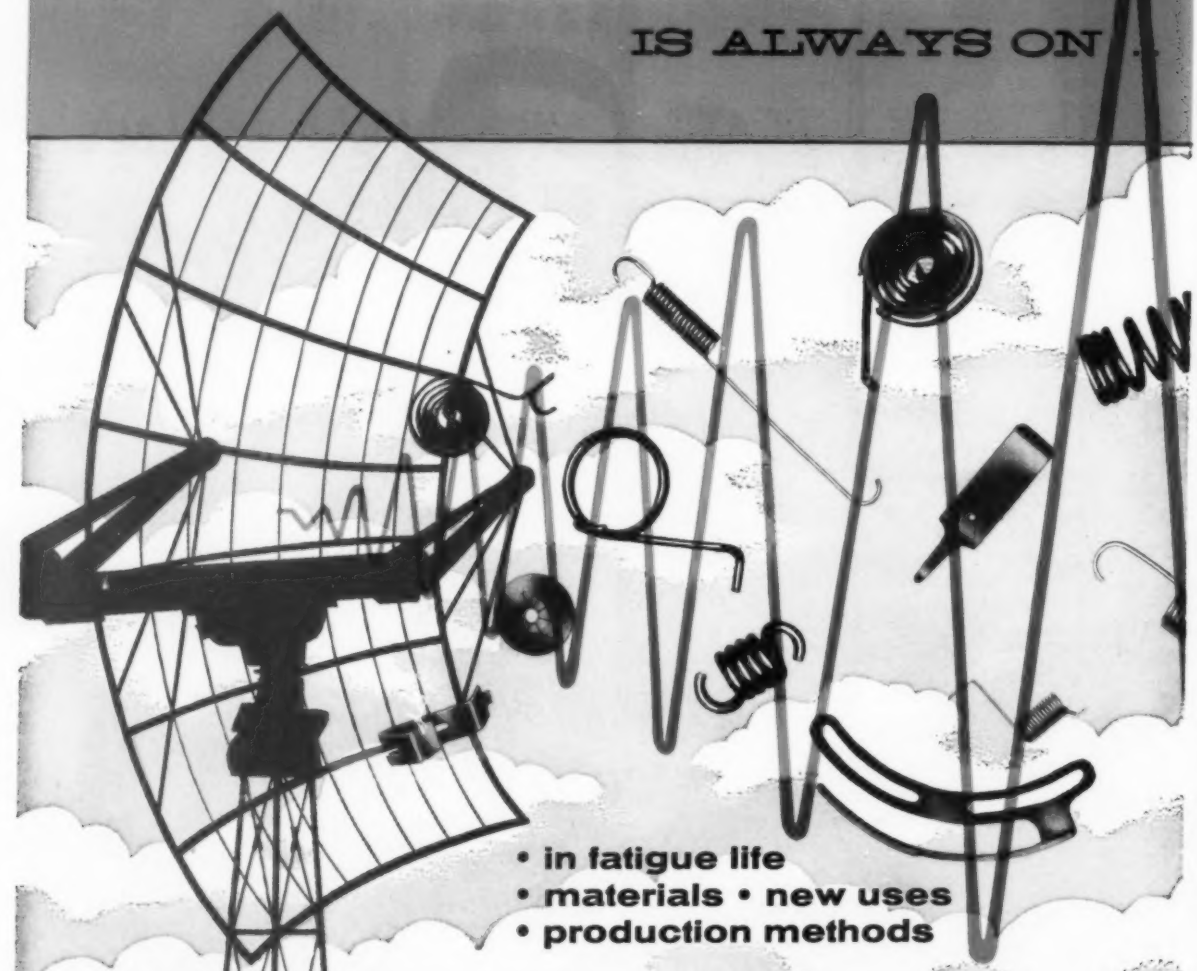
TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

—ITEM 226—

XUM

RESEARCH
IS ALWAYS ON . . .



• in fatigue life
• materials • new uses
• production methods

TO GIVE YOU THE
BEST IN SPRINGS
FIRST

WALLACE BARNES COMPANY, BRISTOL, CONNECTICUT
THE WILLIAM D. GIBSON COMPANY, 1800 CLYBOURN AVE. CHICAGO 14.
RAYMOND Manufacturing COMPANY, CORRY, PENNSYLVANIA
BARNES-GIBSON-RAYMOND, 40300 PLYMOUTH RD. PLYMOUTH, MICH.
B-G-R COOK PLANT, ANN ARBOR MICHIGAN
SEABOARD Coil Spring Div., 15001 S. BROADWAY GARDENA, CALIF.
OHIO DIVISION, 1825 EAST FIRST ST. DAYTON, OHIO
WALLACE BARNES COMPANY, STATE FAIR BLVD. SYRACUSE 9 (Salina), N.Y.
MILWAUKEE DIVISION, 341 E. ERIE ST. MILWAUKEE, WIS.
DUNBAR BROTHERS COMPANY, BRISTOL, CONN.
F. N. MANROSS AND SONS CO., BRISTOL, CONNECTICUT
THE WALLACE BARNES CO., LTD., HAMILTON CANADA

DIVISIONS OF ASSOCIATED SPRING CORPORATION
COAST TO COAST

Divisions of
ASSOCIATED SPRING CORPORATION

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Pillow Block

incorporates rubber-jacketed ball bearings

Rubber-jacketed ball bearing and factory prelubrication ensure quiet operation and long life for this pillow-block assembly. Designated type RPB, the bearing is secured to the shaft by one twist of a self-locking collar. The two-piece, pressed-steel housing is light weight and permits bearing alignment through a range of shaft angles. Pillow blocks are available for shafts from ½ to 1-in. diam; radial load ratings range

from 200 to 300 lb. Rubber-jacketed, ball-bearing cartridges can also be supplied in several styles to fit standard sleeve-bearing brackets. **Fafnir Bearing Co.**, New Britain, Conn.

—Circle ITEM 61

Plastic Pipe

in sizes from ½ to 4 in.

Rigid, unplasticized polyvinyl chloride pipe is nontoxic, odorless, nonporous, noncontaminating, abrasion resisting, and nonflammable. Weight is one-sixth of steel pipe and friction loss is about one-half. Types available are: normal-impact grade with high chemical resistance; high-impact grade with slightly lower chemical resistance but greater strength. Designated

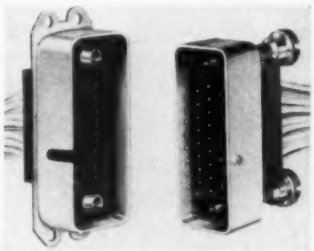
PVC No. 1 and No. 2, both types are furnished with either threaded or socket fittings. Pipe can be formed, sawed, threaded, machined, hot-gas welded, and solvent cemented with standard metal and woodworking equipment. Sizes range from ½ to 4 in. nominal in 10 and 20-ft lengths. **Carpenter Steel Co.**, Alloy Tube Div., Union, N. J.

—Circle ITEM 62

Miniature Connectors

have rectangular housing to save space

Series XMRE miniature external connectors are available with 9 to 72 contacts, which are gold plated over silver for high conductivity. Rating of contacts is 7.5 amp; volt-



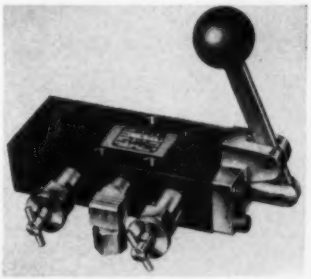
age breakdown between contacts is 4000-v dc at sea level and 1050-v at 60,000 ft altitude. Rectangular aluminum shell conserves installation space and provides protection for dielectric insert and contacts. Insert bodies are mineral-filled melamine, and potting forms can be supplied for encapsulating the connector backs after installation of wiring. Optional accessories are: jackscrew locking device, mounting plates for wall or bulkhead installation, and finger grips for cable-mounted applications. **Winchester Electronics Inc.**, Norwalk, Conn.

—Circle ITEM 63

Throttling Valve

provides speed control for pneumatic actuators

When screwed into control-valve exhaust ports, model 500 throttling



valve provides accurate speed control for air-cylinder pistons. Flow-metering needle can be adjusted and locked without use of tools. Units are available for ¼, ⅜, and ½-in. NPT connections. **Modernair Corp.**, 400 Preda St., San Leandro, Calif.

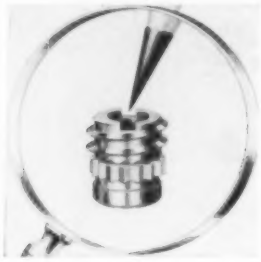
—Circle ITEM 64

Self-Locking Insert

in 4-40 screw size

Miniature-sized and self-locking, NAR 4-40L insert provides a strong internal thread in materials such as aluminum, magnesium, and plastics. It consists of two parts which are installed in a drilled and tapped hole with a screwdriver. Tension high enough to break a 125,000-psi screw will not damage or loosen the

XUM



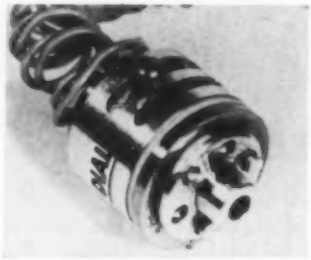
insert. Made of stainless steel, it is available in 4-40 screw size. **Newton Insert Co.**, 1321 E. 17th St., Los Angeles 21, Calif.

—Circle ITEM 65

Torque Control Unit

adjustable in range from 0 to 50 oz-in.

Incorporating an electromagnetic clutch and a slip attachment, this torque control unit is adjustable in the range 0 to 50 oz-in. Torque transmitted is controlled either by adjusting the air gap or by varying the input power. When ganged the units can be simultaneously controlled by a single rheostat. Typical applications include ten-



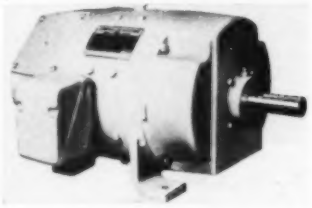
sion control in fine-wire winding operations, film reeling, and high-speed thread winding. Size 100 measures 1⅛-in. diam by 1⅛-in. long; size 130 is 1½ in. diam by 2¾ in. **Dial Products Co.**, 9 Avenue E, Bayonne, N. J.

—Circle ITEM 66

Direct-Current Motor

develops 33 per cent more horsepower per pound

Improved insulation and ventilation in new Kinematic dc motor line has raised horsepower per pound 33 per cent over preceding models. Significant reduction in motor size provides increased power where space is limited and reduces the weight of structural members needed to support the motor. Armature inertia, compared with that of the former line, has been reduced about 35 per cent. Motor ratings from 1 to 150 hp are available, with speed adjustable by field control through the maximum range consistent with good design. Overload capacity has been improved by using a full complement of commutating poles, optimum armature windings, improved brush



rigging, better commutator construction, and new brush grades. Full range of speed and torque is available in the Kinematic line with one-fifth of the number of separate models previously required. **General Electric Co.**, Direct Current Motor and Generator Dept., Erie, Pa.

—Circle ITEM 67

Direct Reading Dial

displays count in large numbers for fast reading

Applicable to any shaft that rotates 3600 deg or less, model 1301 Microdial displays numerical count to three places with an accuracy of 0.1 per cent. Wide-angle observation window and legible numbers permit fast, accurate reading. Since shaft rotation is indicated in turns, tenths of turns, and hundredths of

turns, the dial can also be used as a percentage counter. Diameter of unit is 2 in. and height is 1⅝ in. Readings set by an operator can be locked by means of a finger-tip brake. **George W. Borg Corp.**, Borg Equipment Div., Janesville, Wis.

—Circle ITEM 68

Liquid-Cooled Rectifier

delivers output currents in 540 to 750 milliamp range

Rated at 30 kw, this liquid-cooled germanium power rectifier is applicable where high power output, high efficiency, negligible aging, and small size are required. Cooling is by water or oil at 30-C maximum inlet temperature and 1 to 4-gpm flow rate. Depending on the circuit, output currents range from 540 to 750 milliamp. The rectifier can be supplied for 26 to 66 v rms input. Unlimited service

life can be expected over an ambient temperature range from −55 to 75 C when the rectifier is operated within specified voltage, current, and temperature-rise ratings. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

—Circle ITEM 69

Miniature Transducer

has flush diaphragm

Linearity, hysteresis, and repeatability is ±1.0 per cent or better in model AP-17 flush-diaphragm pressure transducer. Weighing 1½ oz and measuring ¾-in. OD by 1⅜ in. long, the pickup has applications in indicating, recording, and control circuits adapted to operation with variable-reluctance units. Ranges available are 0-15 to 0-5000 psi absolute, and all units are temperature compensated to hold change in calibration to 1.0 per cent full scale for each 100 F variation between −65 and 250 F. Output is 8 mv per volt full scale at 10-v, 300-cps excitation. Natural freqency is 5000 cps for diaphragm

Facing Page—ITEM 228→

are you fighting space?

Are you looking for complete electrical circuit dependability in a very, very small space?

If so, you should use Cannon carefully engineered miniature and sub-miniature multi-contact connectors. In ½ or ⅓ the usual space, they give you up to 50 contacts, the same number as a standard connector, and still retain all the factors of utility, reliability, and mechanical strength found in Cannon's standard size connectors. They are very rugged, easy mating, unusually versatile, neat and compact.

Miniatures — Maximum Dimensions Only 1" x 2"!

first in connectors

CANNON PLUGS

Write for Cannon Miniature and Sub-Miniature Bulletins

Please refer to Dept. 185

CANNON ELECTRIC COMPANY, 3209 Humboldt Street, Los Angeles 31, California.

Factories in Los Angeles, East Haven; Toronto, Canada; London, England.

Representatives and distributors in all principal cities at your service.

THE LATEST NEWS ON POSTFORMED PHENOLITE®

Manufacturers slash assembly time, eliminate rejects, improve products with PHENOLITE parts postformed by NATIONAL

Production speeded, unit costs reduced—from plant after plant comes news of big profits and savings through the use of PHENOLITE parts postformed by National.

Reasons for their cost-cutting efficiency are: (1) National makes PHENOLITE in *many* grades with combinations of service properties unmatched in any other type of material, and (2) National's applications engineers and fabricators are experts at adapting PHENOLITE to specific requirements. We can help you all the way from development of a material—through design—to the delivery of fully fabricated parts.

Want to simplify design and speed production? It will pay you—in reduced unit costs or in product improvement at no added cost—to explore the advantages of special, ready-to-use PHENOLITE parts postformed by National. Send us the problem that's nagging you—and be sure to ask for our new 16-page Catalog on PHENOLITE and other National products. We'll send it promptly, without obligation. Simply write Dept. G-3.

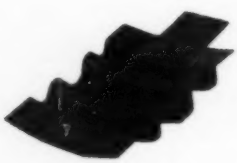
NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada: **National Fibre Company of Canada, Ltd.** • Toronto 3, Ont.

VULCANIZED FIBRE • PHENOLITE LAMINATED PLASTIC • NATIONAL NYLON
PEERLESS INSULATION • KENNETT MATERIALS HANDLING RECEPTACLES • VUL-COT
WASTEBASKETS • LESTERSHIRE TEXTILE BOBBINS • VULCOT PRODUCTS FOR THE HOME

R. F. Bogart, one of National's staff of applications engineers, shown holding a postformed copper clad PHENOLITE printed circuit.

Reverse bends and small radii—toughest problems in forming—were involved in shaping this spring-action, snap-on cover for a switch voltage changer. National's postforming technicians used PHENOLITE C-534-F to achieve a 1/16" radius bend.



Corrugated, bent, and punched after forming, this insulator had to be made of extraordinary stock to withstand unusual stresses. National made use of a double die and PHENOLITE C-534-F to form the corrugated component without cracking or fracturing the piece.

Bending and drawing in one operation were difficulties faced in forming this bus bar joint cover. National ended the trouble by using PHENOLITE X-114-A. PHENOLITE can be formed or deep drawn easily—without damage to the material and without expensive dies.

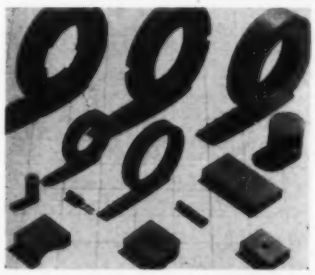
and chamber assembly, and acceleration sensitivity is 1.0 per cent per 100 g in 0-15 psi model. **North American Instruments Inc.**, 611 Wilshire Blvd., Los Angeles 17, Calif.

—Circle ITEM 70

Ceramic Magnets

withstand strong demagnetizing fields

Made of noncritical barium and iron oxides, these ceramic permanent magnets can be furnished in sizes and shapes to meet customer requirements. Characteristics are: energy product, 0.915 gauss-oersteds at 600 gauss working point, resistivity, 6×10^{10} ohms/cm^3; specific weight, 4.85 gm/cm^3. Temperature characteristics are linear (including retrace) to 400 C, and resistance to demagnetiza-



tion is excellent. Ceramic material can be machined by wet grinding after being magnetized. **Stackpole Carbon Co.**, Electronic Components Div., St. Marys, Pa.

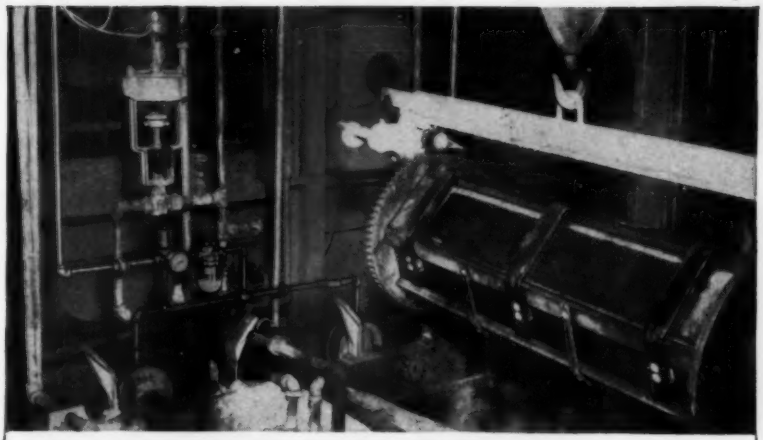
—Circle ITEM 71

Diaphragms

for high-temperature service

Custom molded with single-ply, high-tensile fabric, this convolute diaphragm withstands temperatures to 300 F and working pres-

(*Continued on Page* 162)



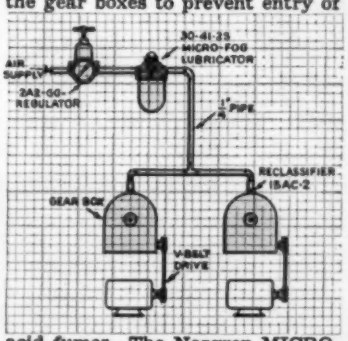
Costly Gear Repairs Ended By Norgren MICRO-FOG Lubrication

. . . Acid fumes "locked out" of gear boxes on plating tanks at Wagner Electric Corporation

The Problem: At the Wagner Electric Corporation, St. Louis, Missouri, baskets containing parts to be zinc plated in a hot acid solution are mechanically agitated by a gear drive.

With the former drip feed lubrication method, acid fumes entered the gear boxes, contaminating the lubricant and destroying the gear box seals. Loss of lubricant, hot-running gears plus corrosion by the contaminated lubricant greatly accelerated gear wear and resulted in frequent costly repairs.

The Solution: Three years ago, the Norgren MICRO-FOG Lubrication System shown in the picture above was installed to lubricate the gear drives on two plating tanks. The Norgren Pressure Regulator maintains a constant pressure in the gear boxes to prevent entry of

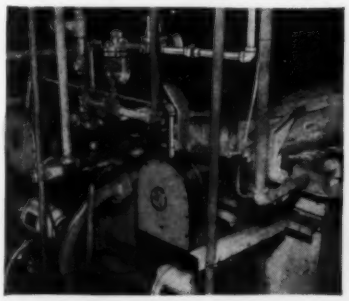


acid fumes. The Norgren MICRO-FOG Lubricator accurately meters oil flow and delivers a continuous fog of fresh, clean oil to the gears.

What Norgren Micro-Fog Is:

Norgren MICRO-FOG is an airborne suspension of extremely small oil particles (.00007874" or less in diameter). Because the oil particles are so small, they can be conveyed long distances through complex piping systems without reclassifying and flooding the lines with oil —a condition formerly not possible with conventional oil-fog systems.

The Results: Norgren MICRO-FOG automatically coats the gears with a continuous film of fresh oil, reducing gear wear and corrosion.



The gear box seal problem has been entirely eliminated because seals are no longer required. Much less lubricant does a more thorough lubrication job—with a substantial saving in lubricant cost. Maintenance costs have been radically reduced.

Without obligation, learn how Norgren MICRO-FOG Lubricators can provide more efficient lubrication and reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory — or **Write the Factory for New No. 700 Catalog.**

C. A. Norgren Co.
3442 So. Elati St., Englewood, Colo.

Pioneer and Leader in Oil-Fog Lubrication Since 1930

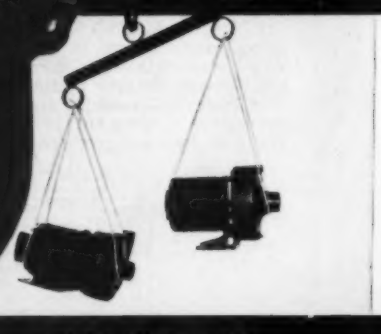
Have you evaluated your

TRIANGLE MFG. CO.
"cut costs 15%"

GAST MANUFACTURING CORP
"30% lighter, but performs bett

ROWE SPACARB, INC.
"saved $3 per unit"

AMERICAN-STANDARD
"cut product size and weight



PACIFIC PUMPING CO.
"helped double sales"

DECORA MFG. CO.
"saved 40¢ per unit on shipping

SWEDEN FREEZER MFG. CO.
"most dependable motor"

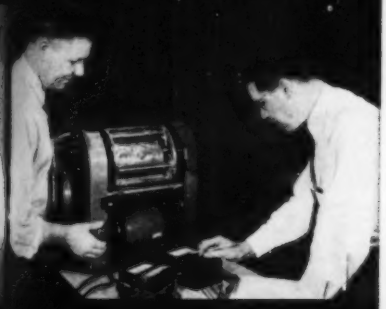
AIRCRAFT-MARINE PRODUCTS, INC.
"extremely low service expense"

DEMING COMPANY
"saved on handling and ship

XUM

motor savings yet?

AMERICAN BLOWER CO.
"reduced motor stocks"



A. B. DICK CO.
"much more value for your money"

UNIVERSAL INDUSTRIES
"helped make peeler portable"

FINNELL SYSTEM, INC.
"100% standardized on G.E."

TODAY THOUSANDS OF COMPANIES CUT COSTS, BOOST QUALITY WITH ADVANCED G-E MOTORS

In the past four years, equipment manufacturers have bought nearly 5,000,000 smaller, lighter G-E fractional-hp motors. Today, they testify to the ***tangible, measurable benefits*** they have realized. For example:

MANUFACTURING AND SHIPPING SAVINGS amounting to about 15% resulted from a Detroit pump manufacturer's* decision to switch to advanced-design G-E motors. Rugged construction of the G-E motor permitted direct mounting, eliminated several parts. Lighter weight reduced worker fatigue, helped speed assembly—shipping and packaging savings alone were 30¢ per unit! Result: a better-looking, more efficient unit which sells at a 10% lower price!

GREATER POWER AT NO EXTRA COST helped a Chicago office machine manufacturer* boost the saleability of his product. Lower handling, shipping, and assembly costs, modern appearance, and the sales value of the G-E monogram cause this well-known manufacturer to credit the G-E motor with making it "easier to design, build, ship, and sell" his machines.

UNSURPASSED DEPENDABILITY of the "years-ahead" G-E motor is a proven fact to thousands of manufacturers. A typical experience is that of a California compressor manufacturer*, who introduced a G-E powered paint sprayer over two years ago. To date 99.9% of these units have never required motor service.

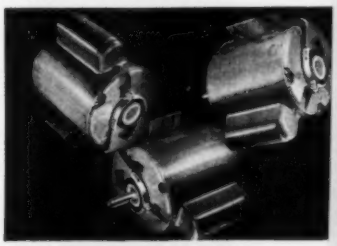
TREMENDOUS SALES APPEAL of products designed to take advantage of all the G-E motor benefits is typified by the case of a West Coast pump manufacturer*. Just one year after introducing a streamlined new unit, made smaller and easier to handle by the G-E motor, his manufacturing costs had been reduced and his ***sales had doubled!***

"Years-ahead" design and proved performance of the G-E motor are helping to establish the leaders in many fields. If you'd like more information, or help in taking greater advantage of the G-E motor's benefits in your products, contact your nearby G-E Apparatus Sales Office, or write to Section 702-24, General Electric Co., Schenectady 5, New York.

**Actual case histories available on request.*
†Dupont trade-mark for polyester film

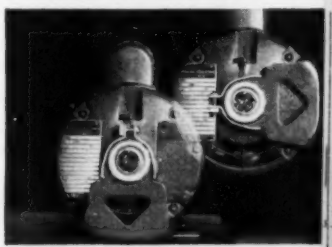
MORE COMPACT—up to 40% smaller, 50% lighter—saves you material and handling costs.

MYLAR† INSULATION (right)—35 times the moisture resistance of paper insulation (left).



ALL-ANGLE OPERATION—protective lubrication in any position—without costly specials.

DOUBLE LUBRICATION LIFE—50% more oil, efficient retention system cut maintenance.

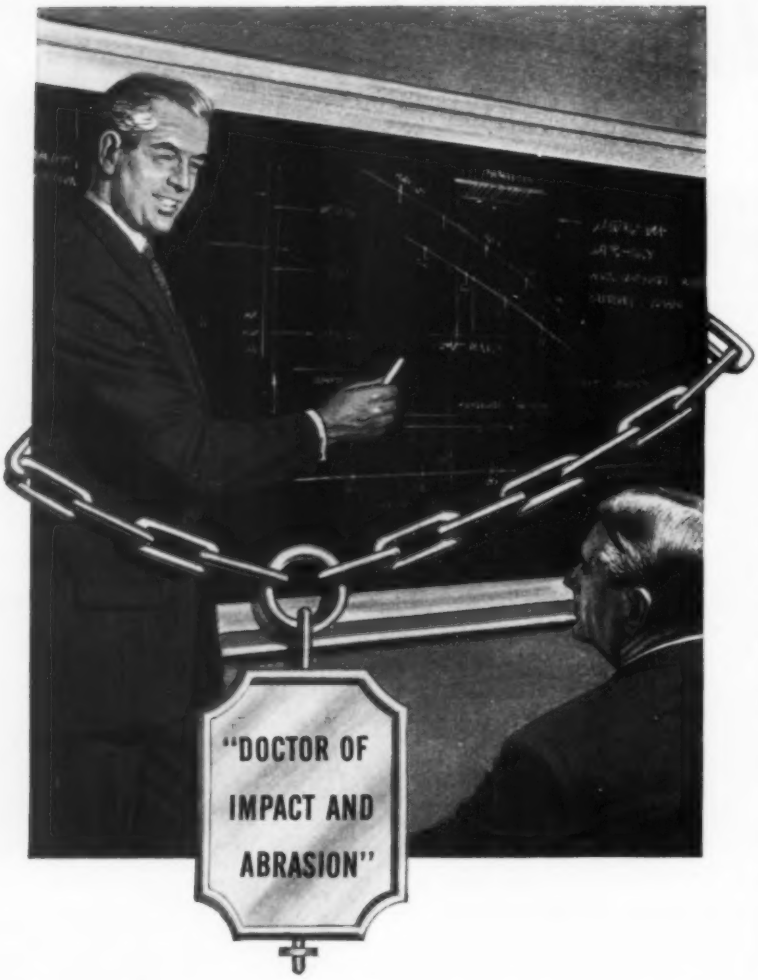


MOUNTING VERSATILITY—rotate motor in resilient *or solid base.* Cradle easily removed.

Progress Is Our Most Important Product

GENERAL ELECTRIC

XUM



Strange title?

Yes, but this man can be a valuable consultant to your engineering staff on severe wear problems. His actual title is—"Amsco Research Engineer."

At Amsco®, solving impact and abrasion problems is our full-time job. We must do it continuously on our own products . . . we help scores of customers with theirs.

Best of all, when you call in Amsco you don't "hire" just one man. You benefit from the combined skill and experience of the *most complete metallurgical and research staff* of any steel alloy producer . . . *plus* the unsurpassed research facilities of Brake Shoe's famous Mahwah Research Laboratories.

We may recommend Amsco Manganese Steel . . . *"the toughest steel known"* . . . as the answer to your problem. Or we may suggest one of many other AMSCO ALLOYS, each with different properties and advantages.

To use our development service, just call your nearby Amsco representative. Or write direct to: Manager of Engineering and Research, Amsco Division, Dept. 322, Chicago Heights, Ill.

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DELAWARE; OAKLAND, ST. LOUIS; JOLIETTE, QUEBEC

—ITEM 232—

New Parts

(*Continued from Page* 159)

sures to 100 psi. Sizes to 30-in. diameter are available. Diaphragm is suited for use in pneumatic or

hydraulic equipment. **Stowe-Woodward Inc.,** Molded Rubber Div., Newton Upper Falls 64, Mass.

—Circle ITEM 72

Gasoline Engine

for heavy-duty applications

Short-stroke, air-cooled engine has a peak output of 12.5 hp at 3200 rpm. Designated K330, it is a single-cylinder, 4-cycle type equipped with flywheel governor, oil-bath air cleaner, silencer-type muffler, fuel pump, oil pressure gage, exhaust valve insert and rotator. Torque

range is from 23.8 lb-ft at 1800 rpm to 20.3 lb-ft at 3200 rpm. Bore is 3⅝ in.; stroke, 3¼ in.; piston displacement, 33.6 cu in. Dustproof and moistureproof, the assembly is easily serviced. Weight is 175 lb. **Kohler Co.,** Kohler, Wis.

—Circle ITEM 73

Centrifugal Clutch

has automatic transmission characteristics

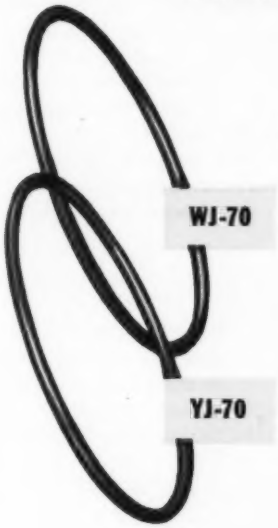
Redesigned for higher capacity, more positive action, and lower cost, V-Plex centrifugal clutch for small gasoline engines provides some of the torque-speed flexibility of an automatic transmission. Clutch control is by throttle action only, with power pickup, full speed,

Elevated Temperatures

Destructive Fluids

Costly Leaks

New LINEAR Compounds Answer Difficult Sealing Questions



Through pioneer research in the utilization of new polymers and elastomers, LINEAR provides new answers to problem sealing applications in hydraulic systems.

Smashes through the thermal barrier! At elevated temperatures, conventional ring packing compounds cannot withstand *Aromatic Fuels, Aroclor, Dow-Therm-A, MIL-L-7808* and other diester fluids. LINEAR "O" Rings molded with WJ-70 compound, were tested up to 78,000 cycles at 500°F. They show absolutely no sign of deterioration . . . no change in the precise dimension of the rings!

Withstands both flammable and non-flammable fluids! LINEAR homogeneous molded parts including "O" Rings, V Rings, Cups or Fabric Reinforced Vee-Dam Rings compounded from YJ-70 provide perfect sealing in hydraulic systems using such fluids as *Skydrol, Pydraul, Lindol,* or mediums that contain *Tri-Cresyl-Phosphate.* In these, as well as in flammable petroleum base fluids, YJ-70 resists deterioration . . . makes packing changeovers unnecessary, regardless of the fluid used.

These new LINEAR compounds have widespread industrial application—may help solve a difficult sealing problem for you. They are additional examples of why it pays you to rely on LINEAR'S experience.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

—ITEM 233—

SPEED TREAT steel cuts time 40%

Finished Corrugated Part Shown at Left

This 12 ton hydraulically operated corrugating machine was built by Mid-City Tool Corp., New Carlisle, Ind., for the Farm Machinery Division of Allis-Chalmers Mfg. Co., LaPorte, Ind.

It is used to corrugate perforated galvanized sheets which are used in harvesting machines. This machine will produce one finished sheet every 8 seconds. Both side plates and the 9 sets of corrugating knives are made of Speed Treat steel plate, heat treated to a hardness of 36 Rockwell C. and ground. Speed Treat constitutes about one third of the total weight of the machine.

This manufacturer estimates that by using Speed Treat Steel, completion time was reduced by 40% due to the free machining characteristics and non-deforming qualities during and after heat treating. Increased tool life and reduced wear on machine tools were other very important factors.

This Indiana manufacturer has expressed extreme satisfaction with the versatility of SPEED TREAT . . . a "time saver" steel.

Note: Speed Steel Plates have "built-in" machinability and fine finishing characteristics.

This means longer tool life, shorter production time and equally important . . . lower overall costs.

THE SPEED STEELS ARE DISTRIBUTED COAST TO COAST BY THESE WAREHOUSES

Beals McCarthy & Rogers, Inc.
Buffalo, N. Y.

Bridgeport Steel Co.
Milford, Conn.

Brown-Wales Co.
Cambridge, Mass.

Burger Iron Co.
Akron • Dayton, Ohio

Grammer, Dempsey & Hudson, Inc.
Newark, N. J.

W. J. Holliday & Co. Division
Indianapolis, Ind.

Earle M. Jorgensen Co.
Los Angeles • Oakland • San Francisco • Houston • Dallas • Tulsa

Peninsular Steel Co.
Detroit, Mich.

Pidgeon-Thomas Iron Co.
Memphis, Tenn.

Horace T. Potts Co.
Philadelphia • Baltimore

Jones & Laughlin Steel Warehouse Division
Chicago • Cincinnati • Louisville

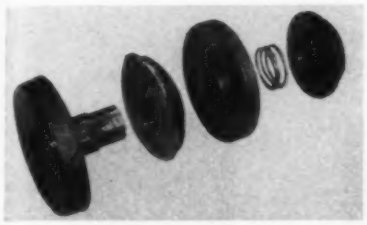
W. J. HOLLIDAY & CO.

DIVISION OF JONES & LAUGHLIN STEEL CORPORATION

SPEED STEEL DIVISION • INDIANAPOLIS 7, INDIANA

—ITEM 234—

For More Information Circle Item Number on Yellow Card—page 19



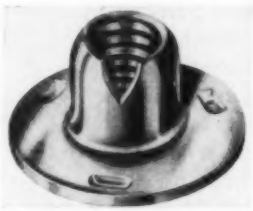
and release being brought about by internal governor weights. Design changes that increase horsepower rating over former models are: increased governor mass, decreased cam angle between clutch cone and weights, and phosphor-bronze idler spring. Transmitting up to 5 hp, the automatic-transmission clutch can be mounted on ½, ⅝, ¾, and 1-in. shafts. **V-Plex Clutch,** Hagerstown, Ind.

—Circle ITEM 74

Self-Locking Nut

has one-piece construction

Locking action of this reusable V-lock nut is due to permanent distortion of the notched barrel and is independent of base load. Manufactured in various styles to customer requirements, it is available in steel, aluminum, and other



metals. Thread is class 2B, either coarse or fine. Finishes are zinc, cadmium, or chrome. Indentations in the base are welding bosses. **Carr Fastener Co.,** Cambridge 42, Mass.

—Circle ITEM 75

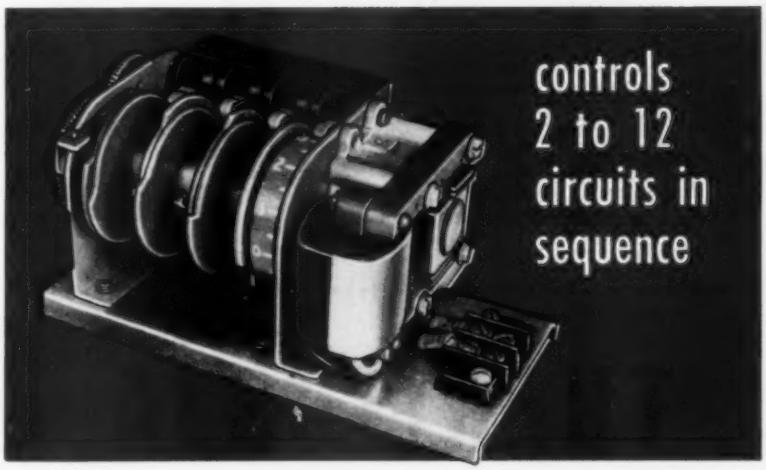
Counter

adds or subtracts at 500 count-per-minute rate

This add-and-subtract electrically operated counter adds at an impulse from one contact switch and subtracts at an impulse from a second switch. Designated model

(*Continued on Page* 168)

EAGLE MULTIPULSE repeat cycle timer



2″ diameter cams adjustable within ½%

This compact Timer features in its construction an "Expandex" hub— an Eagle Signal exclusive. Hub can be loosened or tightened until there's just enough friction between it and the cam shaft to allow moving the cam a hair thickness distance . . . as little as ½% of one revolution. Close settings are further facilitated since the "Expandex" hub eliminates shaft indentations caused by set screws. There is no occasion for a set screw to slip into a previous indentation.

Opening or closing as many as 12 circuits in sequence, the Eagle Multipulse Repeat Cycle Timer is ideal for sequence starting of several motors, timed sequencing of automatic cement block machines, and sequence operation of solenoid valves in washing processes.

Cycle change gears provide 3 to 1 time range. Available with 2 to 12 circuits . . . and with time cycles from 18 seconds to 36. hours. Synchronous motor powered. S.P.D.T. enclosed contacts. Available with cams factory set if desired. Send for free Bulletin 323.

MAIL COUPON TODAY

EAGLE

EAGLE SIGNAL CORPORATION
Industrial Division, Dept. MD-356
MOLINE, ILLINOIS

Please send free Bulletin 323 containing full data on Multipulse Repeat Cycle Timer.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

—ITEM 235—

what are your bearing requirements?

A different demand . . . or set of demands . . . is made of bearings in every different product. Chief considerations may be: minimum noise level . . . corrosion resistance . . . low unit cost . . . wear resistance to oscillating or sliding motion . . . operation in presence of moisture . . . or others. When considering a sintered metal bearing for your product, it is essential that you obtain the correct alloy. The wide range of GRAMIX alloys, together with the long experience of our engineering staff in working with bearing applications, assures you of getting the best possible bearing for your product.

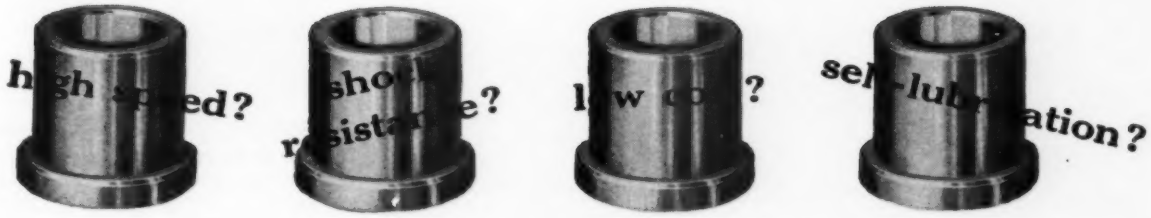
THERE IS A GRAMIX®

(A PRODUCT OF POWDER METALLURGY)

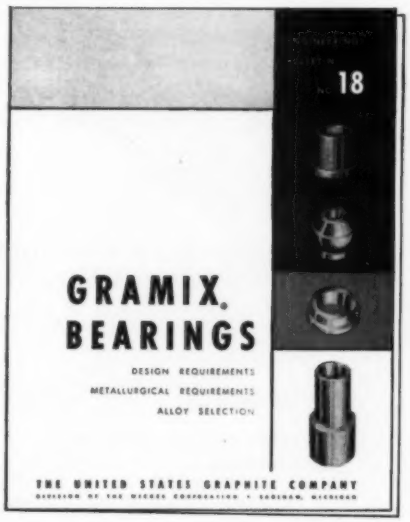
FOR YOUR

Certainly, there is such a thing as a "general purpose" sintered bearing alloy . . . GRAMIX Grade 81 fills this role, and does it well. But there are also applications that demand special alloys, designed to do a specific job better. There is a wide range of GRAMIX alloys to meet every individual design consideration. Properties of these alloys vary widely: tensile strengths range from 8,600 psi to 25,000 psi . . . elongations from 1% to 10%! Operating characteristics also vary. For example, under conditions where there is minimum lubrication, GRAMIX Grade 183 (copper, tin, lead, nickel) is recommended. For heavy duty operation in a surplus of oil, GRAMIX Grade 307 (copper, tin, lead, carbon) is preferred. These few facts convey an idea of the wide design range of GRAMIX alloys. There is *one* that exactly fits your product . . .

THE UNITED STATES



BEARING ALLOY DESIGN REQUIREMENTS



ENGINEERING BULLETIN No. 18

A NEW GRAMIX ENGINEERING BULLETIN TO HELP THE PRODUCT DESIGNER IN SPECIFYING SINTERED BEARINGS

Product engineers who specify bearing materials will find Engineering Bulletin No. 18 of great help. It presents in concise form much of the knowledge we have accumulated since 1924, when GRAMIX was first produced. Design requirements, metallurgical considerations, and alloy selection are all discussed. A table of data on GRAMIX alloy composition and physical characteristics such as density, tensile strength, elongation, and radial crushing strength is included. The section devoted to selecting the right GRAMIX alloy to fit greatly differing product requirements is an ideally simplified guide to this complex subject. Write for your copy of Engineering Bulletin No. 18 today.

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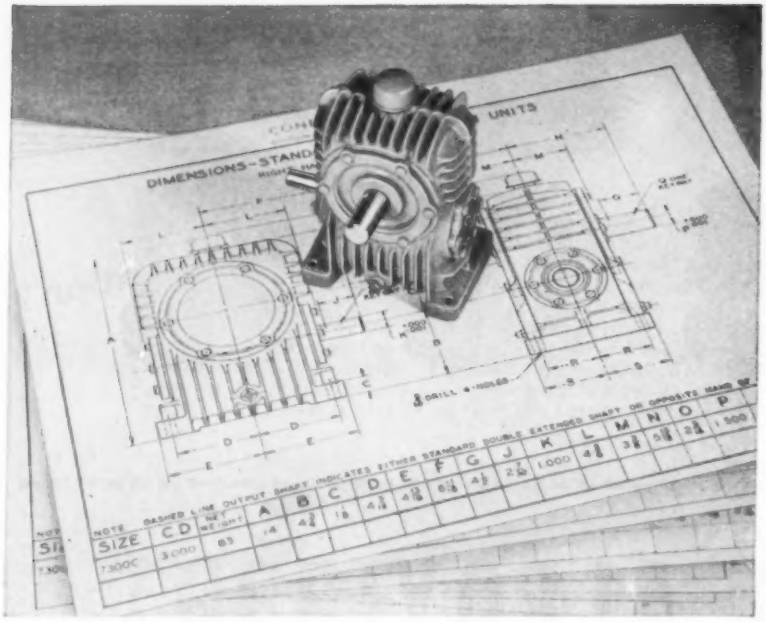
GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

—ITEM 236—



DIMENSIONS ONLY TELL HALF THE STORY...

. . . about worm gear speed reducers. You've got to compare size with load capacity for the whole picture. Inside a Cone-Drive speed reducer you'll find the double-enveloping worm gear design that makes it the most efficient right-angle speed reducer available.

Take the standard 3" center distance unit above for example. Here are its Class I Service Ratings with a 5:1 reduction:

Worm RPM	100	200	300	580	720	870	1150	1750
Mech. HP	1.24	2.21	3.08	4.89	5.61	6.34	7.41	9.04
Thermal HP	1.24	2.21	3.08	4.20	4.62	5.10	6.00	7.80
Output Torque (inch-lbs.)	3340	3010	2830	2405	2250	2150	1940	1575

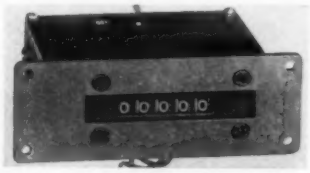
That's a lot of capacity for a unit that occupies less floor space than this magazine page. But it's typical of Cone-Drive speed reducers and gearsets. Complete details on this model in Bulletin 600-C. Other units to 800 HP and ratios to 4900:1.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 237—
For More Information Circle Item Number on Yellow Card—page 19

New Parts

(*Continued from Page* 165)



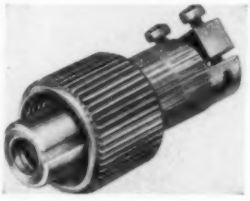
5-Y-8602-MF, it has large numbers for good visibility and hardened steel working parts for long life. Standard operating voltage is 110 v, 60 cycle ac. Maximum count rate is 500 counts per minute. **Durant Mfg. Co.,** 1929 N. Buffman St., Milwaukee 1, Wis.

—Circle ITEM 76

High-Temperature Connector

withstands temperatures to 2000 F

Positive electrical connections are ensured at ambient temperatures to 2000 F by the design of GHR1F-H connector. Suitable for fire detection systems in aircraft or other high temperature applications, the connector is not affected



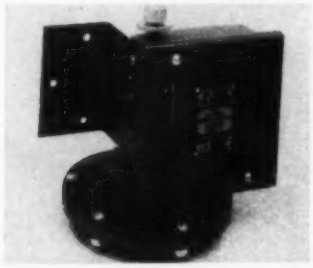
by environmental vibration. **Gorn Electric Co. Inc.,** 895 Main St., Stamford, Conn.

—Circle ITEM 77

Vacuum Switch

operates on low pressure differentials

Vacuum control switch (Cat. 110V) provides vacuum control or warning signal in applications where a specific vacuum must be maintained to prevent a hazardous condition. Range is adjusted by means of a knob located outside the switch housing. Standard units are available with on-off differentials of 0.1± 0.025-in. water or 0.15± 0.05-in. water. Switches withstand maximum pressure of 16 in. water and 10 in. water vacuum. Rating of single-pole, double-



throw contact is 15 amp, 120 to 250 v ac. **Henry G. Dietz Co.**, 12-16 Astoria Blvd., Long Island City 2, N. Y.

—Circle ITEM 78

Self-Aligning Bearing

low-cost unit for radial and thrust loads

Continuous self-alignment during operation is provided by this Clev-Align low-cost bearing. Designed for applications such as construction and farm machinery, blowers, and conveyors, it has a built-in reservoir for life-time lubrication. Corrosion of the shaft is prevented by a nylon bushing, and the bearing is permanently sealed against dirt. Two basic sizes accommodate shaft diameters from ¾ to 1⅜ in. Installation of pil-

low-block or flange models is simplified by an integral set-screw collar, which does not require machining of commercial shaft. **Cleveland Graphite Bronze Co.**, 17000 St. Clair Ave., Cleveland 10, O.

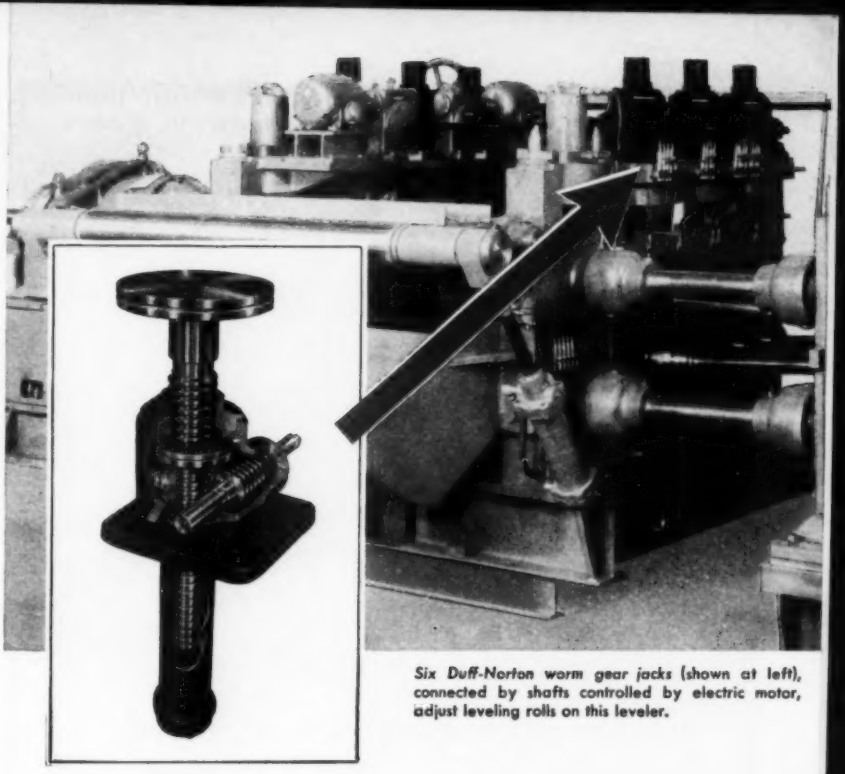
—Circle ITEM 79

Vibration Mount

has 2-cps natural frequency

Vibration isolation of W227 mount is at least 85 per cent at frequencies of 6 cps and up. Stainless-steel wire element provides re-

ITEM 238→



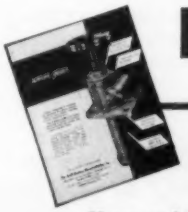
Six Duff-Norton worm gear jacks (shown at left), connected by shafts controlled by electric motor, adjust leveling rolls on this leveler.

Here's a device every machinery designer should know about

It's the Duff-Norton worm gear jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion; applying pressure; resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 45:1; turn of worm for each 1 inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models of these jacks can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton worm gear jacks are made in 6 standard sizes. Write for booklet!



Duff-Norton Company

DUFF-NORTON COMPANY
Department MD
P. O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

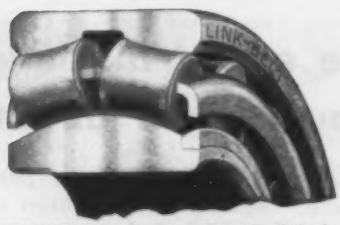
NAME _____ TITLE _____

COMPANY _____ PHONE _____

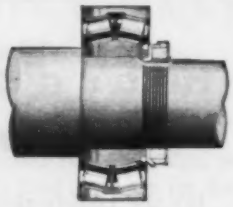
ADDRESS _____

MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

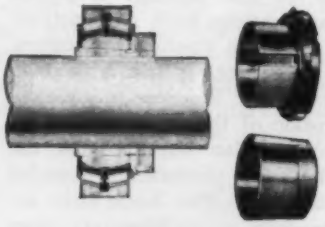
ALLIS-CHALMERS MOTOR GRADER capitalizes on the ability of Link-Belt self-aligning roller bearings to handle high shock loads.



FREE-ROLLING — SELF-ALIGNING. Spherical inner ring is free to align in any direction. Load is distributed over entire roller assuring full load capacity. Destructive edge loading cannot occur.



DIRECT SHAFT MOUNTING with bearing being pressed or shrunk on the shaft. Especially desirable to achieve maximum economy on production applications.



ADAPTER MOUNTING permits use of commercial shafting without machining. Easy installation and removal of adapter-type bearings are provided by the tapered sleeve, locknut and lockwasher.

Builders of industry's heaviest equipment

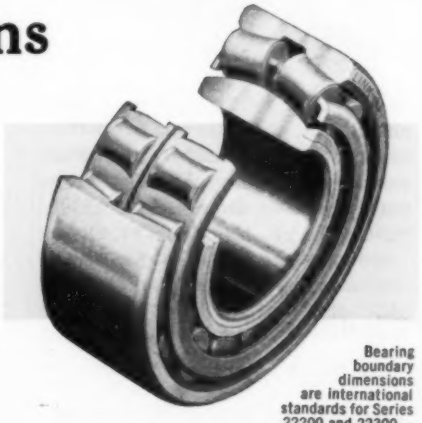
choose this self-aligning roller bearing for toughest applications

You're in company with blue-chip machinery makers when you specify high-capacity Link-Belt self-aligning roller bearings. Wherever tough-duty equipment calls for self-contained, pre-adjusted bearings and simple mounting, you'll find them on the job . . . handling heavy radial and thrust shock loads.

These self-aligning roller bearings have internationally standardized boundary dimensions and are available everywhere. Link-Belt also makes industry's most complete line of ball and roller bearing blocks. This includes pillow blocks plus flange, flange cartridge, cartridge, take-up and hanger blocks. Ask any one of the 40 Link-Belt offices for data Book 2550.

LINK-BELT

Ball and Roller Bearings 13,303-A



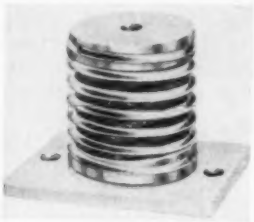
Bearing boundary dimensions are international standards for Series 22200 and 22300—22500-A and 22600-A.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

—ITEM 239—

For More Information Circle Item Number on Yellow Card—page 19

silience and ensures high degree of damping. Designed for a static load deflection of 2½ in., the unit has 2-cps natural frequency. Applications include vibration isola-



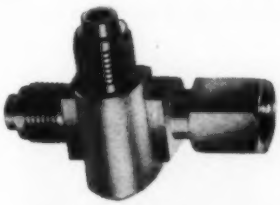
tion of pumps, air compressors, motors, and similar industrial or laboratory equipment. **Robinson Aviation Inc.**, Teterboro, N. J.

—Circle ITEM 80

Dual Drive Adapter

provides two gear ratios from one power source

Circle Ess dual drive adapter provides two gear ratios from the same power source and is usable with flexible shaft drives for driving more than one unit from the same power source. Adapters are equipped with threaded connec-



tions having 0.104-in. internal square drives and in ratios of 1:1, 15:1, 16:1 and 17:1, for either left or right rotation. Body of the 4-oz unit is aluminum alloy, and connectors are brass. Hardened steel gears run in permanently lubricated bearings. **F. W. Stewart Corp.**, 4311 Ravenswood Ave., Chicago 13, Ill.

—Circle ITEM 81

Flexible Tubing

in seamless aluminum or bronze

Flexible seamless aluminum tubing is now available in sizes from ¼-in. to 2 in. ID; smaller or larger sizes can be made to order. Bronze

DESIGNERS

if you have a dead-end job

send us your telephone number

If you are stuck in a job without a future, it will pay you to investigate the wide variety of openings in our engineering department.

Here, the designer is a key man. He has a virtually unlimited opportunity to gain recognition and advancement. Outstanding men can, and frequently do, build sound, well-rewarded careers in a hurry.

In addition, there are other important advantages: new, higher salary ranges, liberal employee benefit programs, pleasant New England living, many others.

Fill in and mail the attached coupon immediately. We'll treat it confidentially; reply without delay. Your action now may be the first step toward a far better future for you and your family.

Be sure and include your telephone number. We may want to call you.

Mr. E. M. Peterson
Dept. 4, Design Employment
Pratt & Whitney Aircraft
East Hartford 8, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

☐ Nuclear Design
☐ Compressors
☐ Turbines
☐ Structures
☐ Afterburners and Related Equipment
☐ Aerodynamics
☐ Hydraulics
☐ Gears
☐ Valves
☐ Heat Exchangers and Combustion Problems
☐ Bearings
☐ Piping
☐ Controls
☐ Test Equipment
☐ Test Rigs
.....

Total years Mechanical Design experience .....

You can reach me at ..... (telephone) Most convenient hours for receiving calls are between ..... and .....

NAME .....
ADDRESS ..... STATE .....
CITY .....

PRATT & WHITNEY AIRCRAFT
Division of United Aircraft Corporation
East Hartford 8, Connecticut

World's foremost designer and builder of aircraft engines

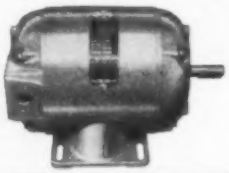
SAVE

on original development costs
by using REULAND ELECTRIC'S

SPECIAL-MOTOR "LIBRARY"

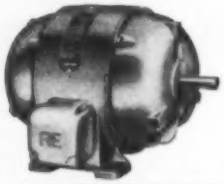
Over 900 Different
Electric Motors

MOTOR #810



CAN BE STALLED OR "LOCKED" WITH CURRENT ON without damage. This torque motor automatically adjusts to intermittent load changes, yet maintains constant power. Available in locked service duties of 5%, 10%, 25%, 50% and 100% with maximum stalls of 5, 10, 20 or 60 minutes, *or continuous* stall.

MOTOR #569



MULTI-SPEED MOTOR operates at different speeds as desired. Available in 2, 3 or 4-speed ratings in the following types:
Constant Torque—Constant torque regardless of motor's speed.
Variable Torque — For loads that maintain their own momentum.
Constant H.P.—Constant H.P. even at reduced motor speed.

MOTOR #617

WAFER-THIN, AIR COOLED, TOTALLY ENCLOSED. Originally designed for ventilation and air moving installations where it could be direct-connected to the fan *within* the piping or vent. Direct-fan attachment eliminates pulleys, belts, brackets and fan shaft. Can also be supplied in open type for mounting out of airstream.

MOTOR #402

HIGH STARTING TORQUE ON LOW STARTING CURRENT, plus variable speed are offered by the Slip Ring motor. Often permits using regular current for getting heavy loads up to full speed. Cranes, heavy fans, printing presses and crushers are typical uses. Available separately or with single or double reduction gear reducers.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY . . .

Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

RE REULAND ELECTRIC COMPANY
Distributors In All Principal Cities
Western Division: Alhambra 25, Calif. — Eastern Division: Howell 25, Mich.

New Parts

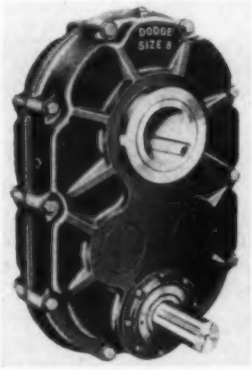
flexible-tubing sizes range from 1/16 to 8 in. ID. Lengths to 10 ft are available. Depending on internal pressure and operating conditions, tubing has open or close pitch convolutions, and is furnished with or without metallic braid jacket. Unit illustrated has 9-in. overall length, open pitch convolutions, and integral cylindrical ends. Various end connections can be specified. **Seamlex Co. Inc.,** 4123 24th St., Long Island City, N. Y.

—Circle ITEM 82

Speed Reducer

is shaft mounted

Foundations, flexible couplings, and sliding bases are not required with this speed reducer. Mounted directly on the shaft, it is anchored to any fixed object by its torque arm. New reducers available are No. 11 (1.3 hp at 100 rpm) and No. 8 (60 hp at 100 rpm). Output speeds are from 12 to 365 rpm. Supplied as optional equipment are an auto-



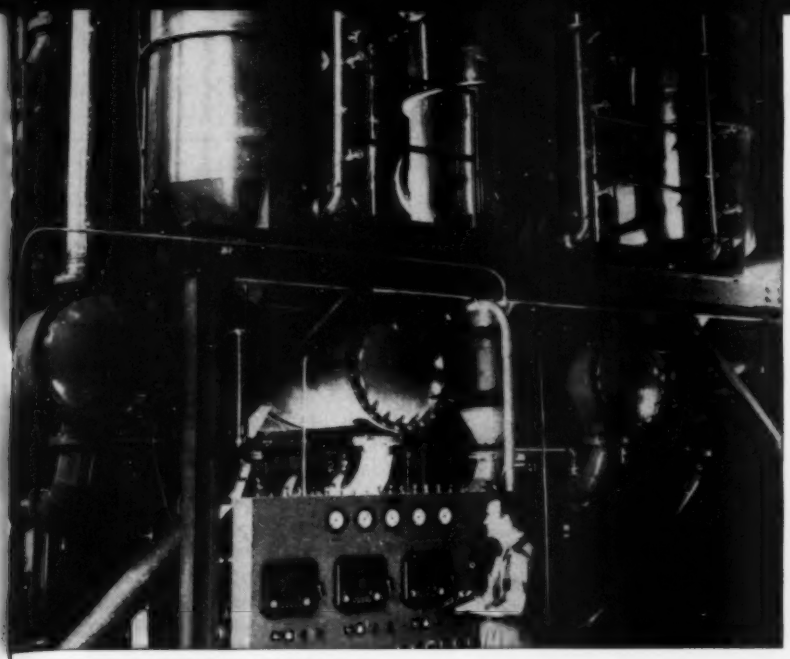
matic overload release and an integral backstop for use where reversal of rotation must be prevented. **Dodge Manufacturing Corp.,** Mishawaka, Ind.

—Circle ITEM 83

Split-Flange Connectors

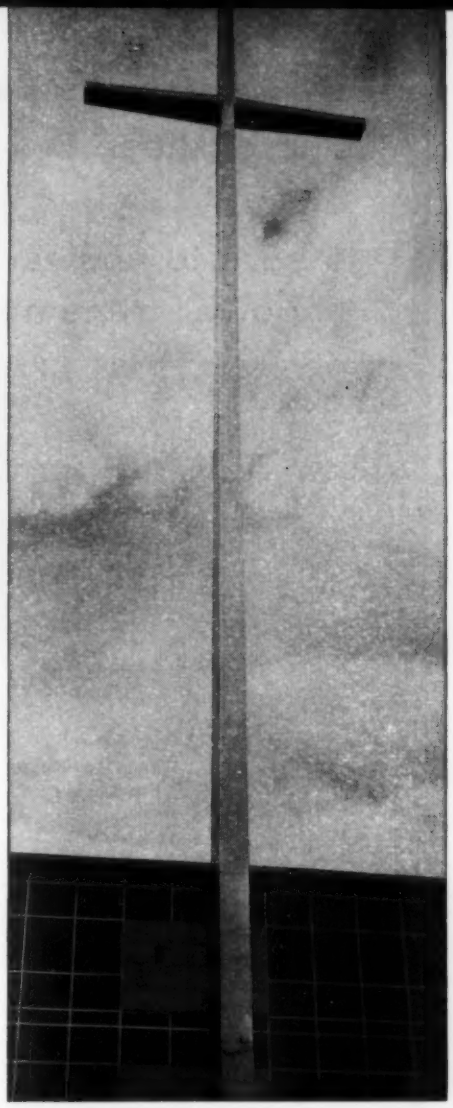
for fluid or gas lines

Line of split-flange connectors provides leak-proof joints that are un-



FOR CORROSION RESISTANCE. The Marathon Corporation developed a method of producing lignosulfonates from paper mill sulfite liquor, but it was impractical until Stainless Steel became available in the 1930's. The plant now produces 75 million pounds a year, and 50% of the equipment is Stainless Steel.

NOTHING *can equal* *Stainless Steel*



FOR ENDURING BEAUTY. This great religious symbol is erected on the grounds of St. Patrick's Academy, Chicago, Ill. The Stainless Steel skin furnishes a gleaming, permanent inspiration to all viewers.

• No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When buying Stainless, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

FOR WET, ABRASIVE SERVICE. Here's a Stainless Steel shaker screen in a coal plant. Management says, "Ordinary screens would only last about two weeks, but we can expect three *years* of service from these Stainless Steel screens . . ."

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

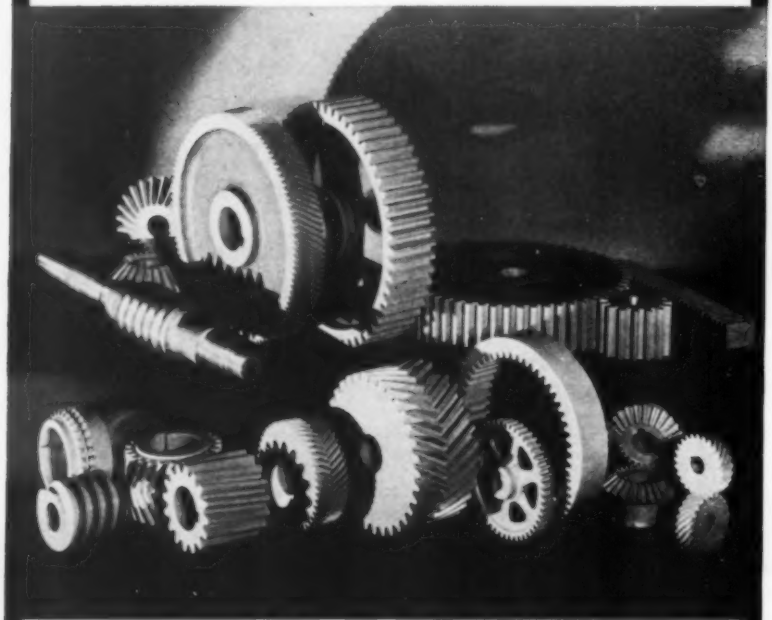
UNITED STATES STEEL

XUM

One of these 9

H&S Gears

is sure to answer your power transmission needs!



Spur • Racks • Bevel • Mitre • Internal • Worm • Helical • Spiral • Herringbone

Regardless of type, every H & S Gear is of the rugged, "husky" type. Heavy rims are well reinforced. Hubs are heavy in section, eliminating the need for key patches. All sharp corners are broken and generous fillets are provided.

H & S Gears are available of Steel, Hardened Steel, Alloys, Cast Iron, Bronze, Rawhide, Fibroil, or Bakelite.

Exacting care is exercised in every manufacturing step of H & S Gears. This insures *quietness of operation, uniform velocity ratio,* and *freedom from vibration.*

Whether you need a gear that weighs one ounce or 10 tons, why not put our years of gear engineering experience to work for you. Just send us the specifications or call. There's no obligation.

THE HORSBURGH & SCOTT CO.

GEARS AND SPEED REDUCERS

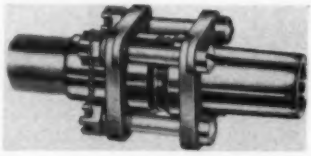
5112 Hamilton Avenue

Cleveland 14, Ohio

Send note on Company Letterhead for complete H & S Catalog

—ITEM 243—

New Parts



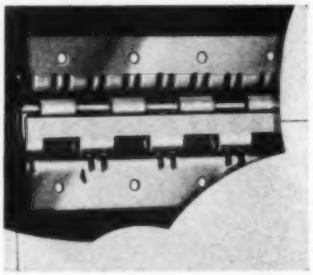
affected by twisting of the tubing. Made for tubing sizes to ¾-in., the connectors are compactly designed to permit installation in a restricted space. Alloy steel construction is suitable for use with lines carrying hydraulic or corrosive fluids, gas and steam. Necessary bolts, nuts, sleeves, sleeve adapters, and tube seals are supplied to suit the style ordered. **Barco Mfg. Corp.,** 500-530 N. Hough St., Barrington, Ill.

—Circle ITEM 84

Hidden Hinge

has no visible elements

Designated No. H-90, this unit will attach any small access cover or door to exterior panels of original equipment. It has a smooth exterior with no visible elements. Maximum depth of ½-in. behind panel surface is required for installation. Rotation of door panel



is 145 deg. Hinge action tends to hold door open to allow full access. Hinges are available in lengths from 2 to 6 in. for a variety of frame and door thicknesses. **Hartwell Co.,** 9035 Venice Blvd., Los Angeles 34, Calif.

—Circle ITEM 85

Stake Nut

for heavy-duty use

Improved design multiple-thread stake nut is intended for applications where vibrations and loads are heavy. It combines the assembly advantages of a clip nut and

CORNING GLASS BULLETIN FOR PRODUCT DESIGNERS

CORNING GLASS WORKS, 52-3 Crystal Street, Corning, New York
Please send the material checked below:
☐ Illustrated booklet: "Glass and You."
☐ Bulletin B-83: "Properties of Selected Commercial Glassware."
☐ Bulletin B-84: "Manufacture and Design of Commercial Glassware."
Name_____
Title_____
Company_____
Address_____
City_____ Zone_____ State_____

How to make a point—painlessly

In the syringe behind the needle, which your dentist wields so deftly, is a neatly prepackaged dose of anesthetic. These containers are glass tubes stoppered at both ends.

We call these painkiller packages "cartridges," and fashion many of them of a PYREX brand glass. The specific glass used goes under the somewhat undramatic name of glass No. 7740.

While the title may be lacking in imaginative quality, the glass is not. Consider, for a start, the fact that the glass cartridges must be made to close inside-outside tolerances because (a) rubber stoppers must fit snugly inside and (b) the cartridge itself needs nestle neatly in the dentist's hypo or syringe.

These close fits demand fire polishing the ends (so they won't chip) without impairing dimensional tolerances—quite a delicate operation for mass production.

The glass tube must be capable of being sterilized without undue strain or breakage; it must be chemically inert so it neither adds to nor detracts from the quality of its contents. And the cartridges must be economical as, in the interests of sterility, they are used once and discarded.

So far, so good. This PYREX brand glass No. 7740 meets all the counts—and then some. It's a glass that's easily formed into intricate shapes, by varied methods, including inexpensive, one-piece molding.

For most general purpose use, No. 7740's reluctance to interfere with chemicals is without peer. Its unusual thermal expansion coefficient (33 x 10^{-7} between 0 and 300° C.) gives it a better than fighting chance with the temperatures encountered in a wide range of design problems.

And certainly of importance, the fact that countless customer-conceived projects have *proved* its profit worth.

We recommend for your reading a copy of Bulletin B-83, "Properties of Selected Commercial Glassware." Within the 14 pages of this unpretentious volume you'll find detailed, for a number of our glasses (No. 7740 included), data on mechanical properties, thermal stresses, heat transmission, and electrical and chemical characteristics. Free. Much easier with the coupon.

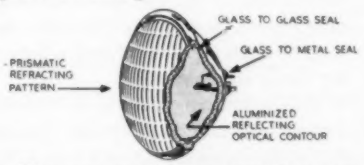
Stray rays . . . the care and handling thereof

Selective maneuvering of rays in the visible spectrum has traditionally been one of the roles that glass plays with considerable success.

Now comes another improvement in this field—one that adds comfort and safety to your motoring and, conceivably, some valuable facts to your files on glass utility. It's the new sealed-beam headlight which reduces the hazards of driving at night and in the fog.

The glass lens and reflector of the new headlight, sealed together hermetically, are designed to reduce stray rays, to concentrate more light—further ahead on the high beam and to the right of the road on the low beam.

Sounds like a simple achievement, but it took several years to accomplish and involved significant contributions of automotive, lighting, and Corning glass engineers working together on lens design, reflector design, and filament design. Corning now makes these prismatic lenses and the reflectors for several headlight manufacturers, one of whom even includes three aligning knobs on his lens, which contribute to easier and more positive focusing.



The new sealed-beam headlight illustrates how you can engineer glass to maneuver light into places where it does the most good. It also illustrates high perfection in hermetic sealing—glass-to-glass and glass-to-metal. The sealed-beam headlight is as airtight as a lamp bulb.

You can glean more about the nature and extent of engineered glass accomplishments, in *many* fields, from an attractive little primer called "Glass and You." We'll gladly send you a copy—free.

Or, Bulletin B-84: "Manufacture and Design of Commercial Glassware." Contents follow the title, offering suggestions for matching design to known advantages (as well as limitations) of various processes. The coupon will bring them to your drawing board or desk.

The big payoff?

Here's a quiz that may get you prizes galore in the form of money made (or saved). This is a matching game, aimed at showing you how one just-right Corning glass handles a difficult problem.

Write the number of the appropriate glass in the box following each description.

Protects light-sensitive substances from wayward and annoying angstroms. ☐

Conducts electricity and provides uniform heating surface. ☐

Protects against radiation effects as effectively as concrete; is nonbrowning; has density of 3.3. ☐

Can be used with intermittent temperatures to 1200° C.; has thermal coefficient of expansion of 8 x 10^{-7} per °C. ☐

Absorbs visible light from tungsten filament (2700° K.) but transmits infrared. ☐

1. VYCOR brand Glass No. 7910
2. Low Actinic Glass
3. Corning Code No. 8362 Glass
4. Corning E-C Glass
5. VYCOR brand Glass No. 7950

Correct answers: 2, 4, 3, 1, 5.

And that's just a start. There's also ribbon glass that outperforms mica; glass that's brick-wall thick or eggshell thin; glass that handles metal-eating acids without ill effects; glass that copes with almost any form of radiant energy—glass that improves performance of and often adds beauty to many, many, many products.

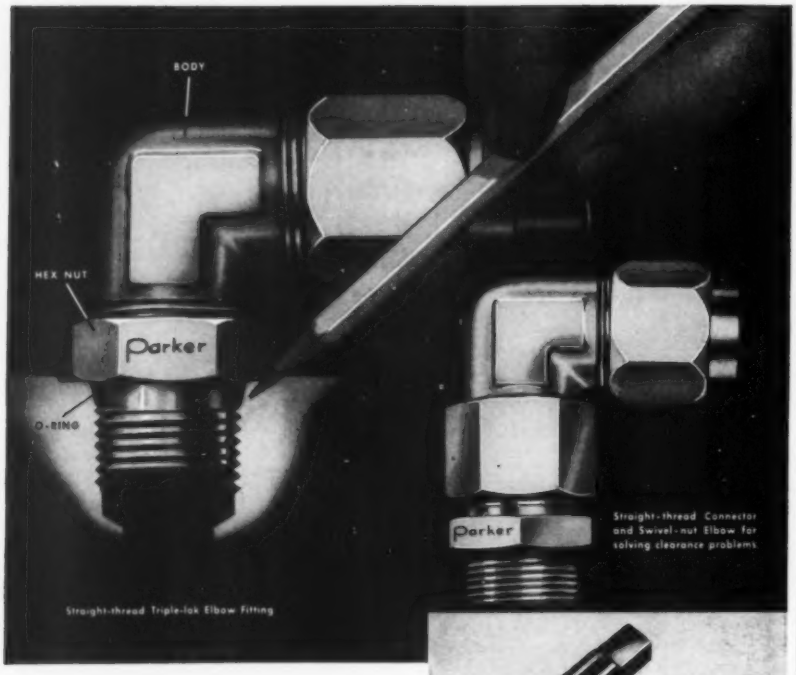
Jot down your most vexing problem and we'll let you know if one of our glasses can help you solve it.

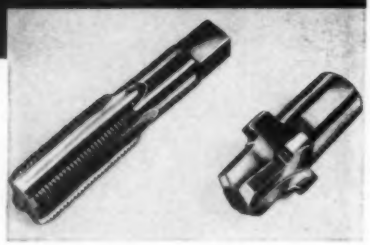
CORNING GLASS WORKS, CORNING, N. Y.

Corning means research in Glass

—ITEM 244—

XUM





Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

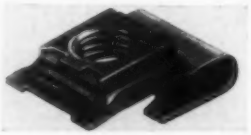
This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Write for Cat. 4301.

TUBE AND HOSE FITTING DIVISION
Section 414-K
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

—ITEM 245—

New Parts



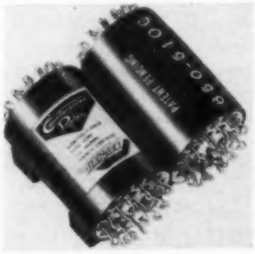
the holding power of a multiple-thread nut. Formed catch on the lower leg positions the nut and acts as a lock washer when assembly is completed. Stake nuts are available in various sizes. **Eversole-Lentz Inc.**, 4231 Monroe St., Toledo 13, O.

—Circle ITEM 86

Tandem Relay

switches 24 circuits

Double-throw relay switches 24 circuits with a 2-amp, 28-v dc resistive load. Envelope size is 1 23/32 x 2½ x 1 5/16 in. Unit exceeds vibration requirements of Mil-E-5272, procedure 1 (10 to 500 cycles per second, 10 g), 50 g shock test and 30 g acceleration. Total weight is 10½ oz; size, less than 5 cu in. Also available are a 12-pole, double-throw design, a relay for 400 cycle input, and several designs for



special applications. **Cook Electric Co.**, Diaphlex Div., 2700 N. Southport Ave., Chicago 14, Ill.

—Circle ITEM 87

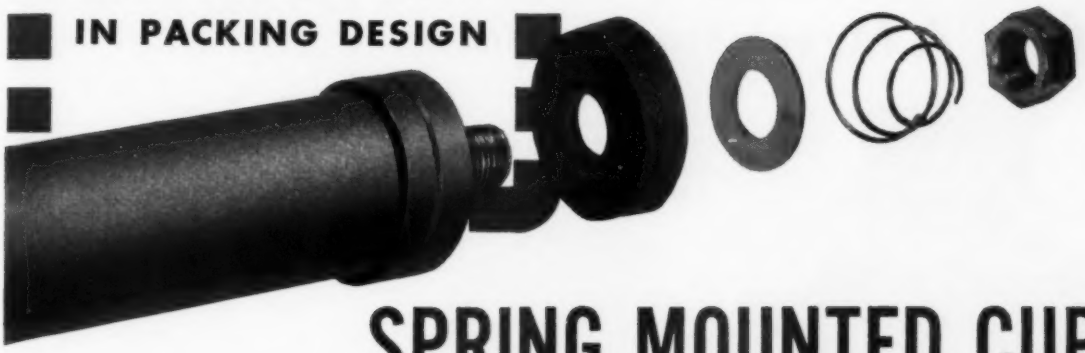
Sheet Metal

in three-dimensional patterns

Decorative RIGID-tex metal sheets are produced in several new patterns for use as appliance trim, dial plates, vehicle interior trim, and similar applications where three - dimensional pattern is desired. Representative new patterns are basket weave, light and heavy shadow box, hammered, and alternate concave and convex. Sheet widths are to 36 in., depending on pattern, and material can be stain-

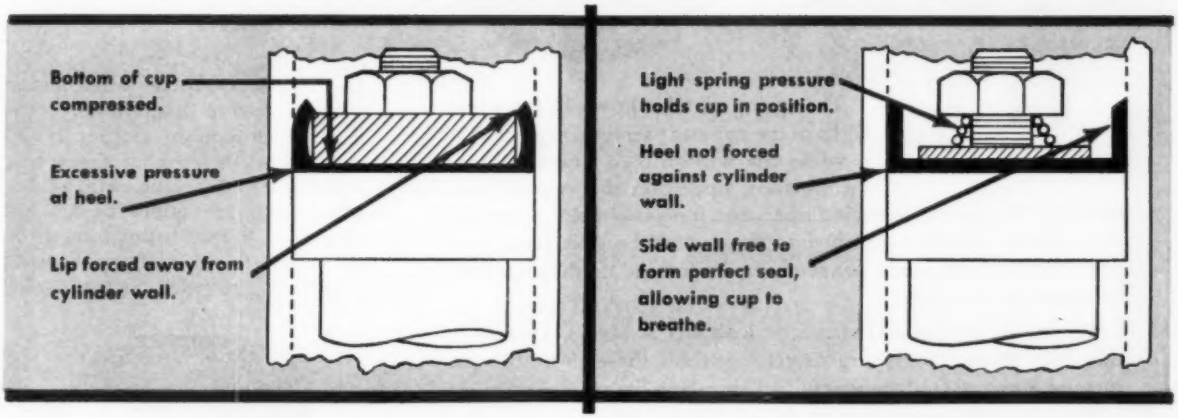
For More Information Circle Item Number on Yellow Card—page 19

ANOTHER
NEW DEVELOPMENT
IN PACKING DESIGN



SPRING MOUNTED CUPS

Provide Better Seal.....Reduce Friction


Bottom of cup compressed.
Excessive pressure at heel.
Lip forced away from cylinder wall.
Light spring pressure holds cup in position.
Heel not forced against cylinder wall.
Side wall free to form perfect seal, allowing cup to breathe.

Houghton hydraulic research has come up with one of the chief answers to the problem of excessive friction, short cup life and chatter so often encountered in cup packing installations. Now, instead of the squeezing action of bolting the cup packing in place between the piston and the follower plate, you can use a spring mounting with preformed cup packings. The illustrations show the obvious advantages.

This leadership in hydraulic know-how is typical of Houghton, which makes all types of hydraulic and pneumatic packings, as well as a complete line of hydraulic oils and fluids.

Standardize on Houghton. You'll get the newest first—and the best always. Call your Houghton Man. He will explain their Hydraulic Service. E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

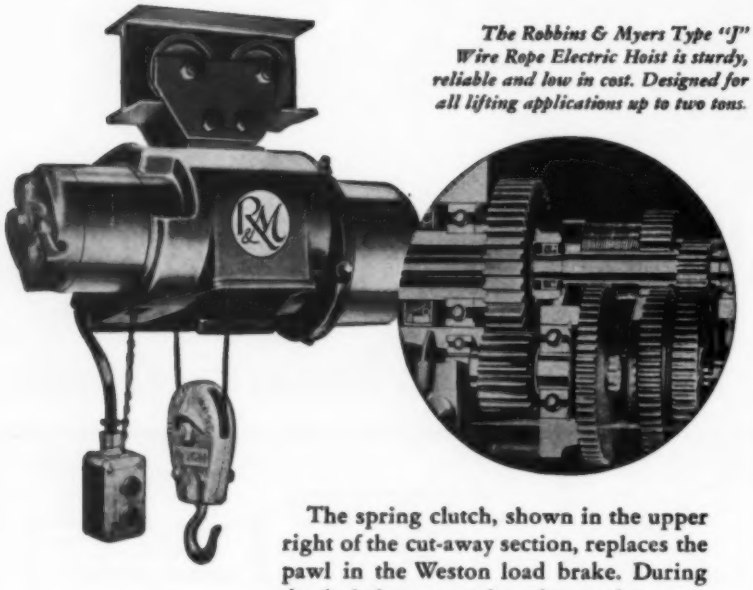
. . . products of

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

—ITEM 246—
For More Information Circle Item Number on Yellow Card—page 19

Marquette SPRING CLUTCHES
assure dependable operation in Robbins & Myers Electric Hoists



The Robbins & Myers Type "J" Wire Rope Electric Hoist is sturdy, reliable and low in cost. Designed for all lifting applications up to two tons.

The spring clutch, shown in the upper right of the cut-away section, replaces the pawl in the Weston load brake. During the hoisting operation the ratchet must turn, but during the lowering operation it must be held stationary. The spring clutch is attached to the ratchet by gear teeth, thus providing a continuous connection and instant holding as soon as lowering is started.

The Hoist & Crane Division of Robbins & Myers, Inc. states that "the Marquette Spring Clutch provides these desirable features in a compact, dependable and simple unit".

There's a Marquette Spring Clutch for almost every purpose—over-running or free-wheeling... indexing... reversing... single revolution... delayed action... and bi-directional no-back brakes. They are low cost, compact and trouble-free.

There are no restrictions on torque. Actual designs range from 6 in. lbs. to 25,000 ft. lbs. Speeds? From 1 to 10,000 r.p.m.

The Marquette
METAL PRODUCTS CO.
SUBSIDIARY OF CURTISS-WRIGHT CORPORATION

ALSO MANUFACTURERS OF: ROLLER BEARING TEXTILE SPINDLES • HYDRAULIC GOVERNORS • PRECISION PARTS AND ASSEMBLIES • AIRCRAFT WINDSHIELD WIPERS • FUEL OIL PUMPS & INJECTORS • ROTARY HIGH PRESSURE OIL FIELD PUMPING MACHINERY

A PRODUCT OF CW CURTISS-WRIGHT

THE MARQUETTE METAL PRODUCTS CO.
1141 Galewood Drive, Cleveland 10, Ohio

Please send manual describing the functions, applications and operations of the basic types of Spring Clutches.

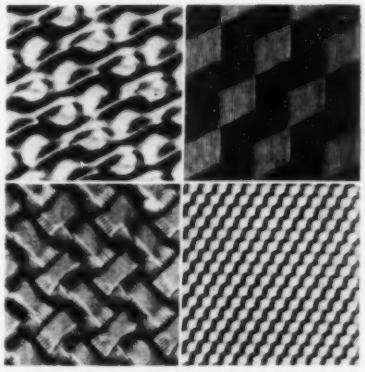
COMPANY_____

NAME_____ TITLE_____

ADDRESS_____

—ITEM 247—

New Parts



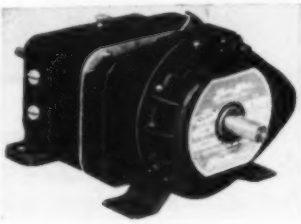
less steel, aluminum, or almost any other metal. **Rigidized Metals Corp.**, 693 Ohio St., Buffalo 3, N. Y.

—Circle ITEM 88

Speed Reducer

is infinitely variable from true zero to maximum ratio

A fixed-ratio gear box and a Zero-Max variable-speed transmission are combined in this infinitely variable speed reducer. Output is adjustable while running from true zero to the maximum ratio of the unit. Gear reductions to 5:1 are available; torque ratings are from 20 to 100 lb-in. Input and output shafts are parallel, and the output shaft (½-in. diam) rotates counterclockwise on standard models. **Revco Inc.**, 1900 Lyndale Ave. South, Minneapolis, Minn.



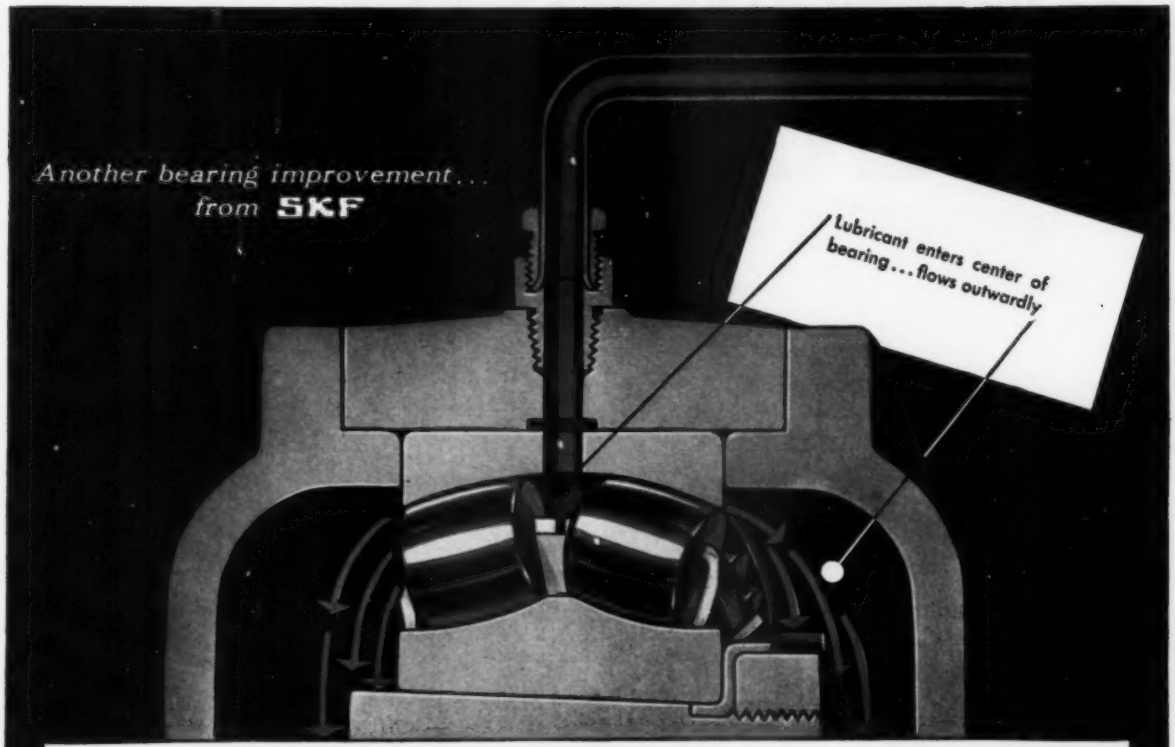
—Circle ITEM 89

Small Induction Motor

ball bearing equipped for low-temperature service

Quick starts at temperatures from −40 to 130 F are provided by this ball-bearing, fractional-horsepower induction motor. Designed for outdoor use, series 500 motors are available with final shaft speeds

(*Continued on Page* 183)



NOW AT NO EXTRA CHARGE-

SKF's improved method of lubricating large spherical roller bearings

To make the lubricant effective it should be located where needed—in the bearing. Also, new lubricant, when added, should enter where it does the most good—in the bearing.

For these reasons, all future production of SKF double row spherical roller bearings above 240 mm O.D. (9.4488") will be made with three equally spaced drilled holes in the center of the outer ring without any extra charge to our customers. *This permits the lubricant to enter the center of the bearing.*

With the lubricant (either grease or oil) being introduced into the center of the bearing, all working surfaces are quickly and completely covered. In addition, the outward flow flushes out the old lubricant, and with it, any abrasive dust, dirt, moisture or other impurities.

And where circulating oil lubrication is required, there is a continuous flushing and cooling of the bearing.

This is another example of how SKF helps you to obtain longer bearing life.

YT00

Consult your SKF District Office today for complete information so that you can be the first to incorporate into your products this improved method of lubricating large spherical roller bearings.

SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

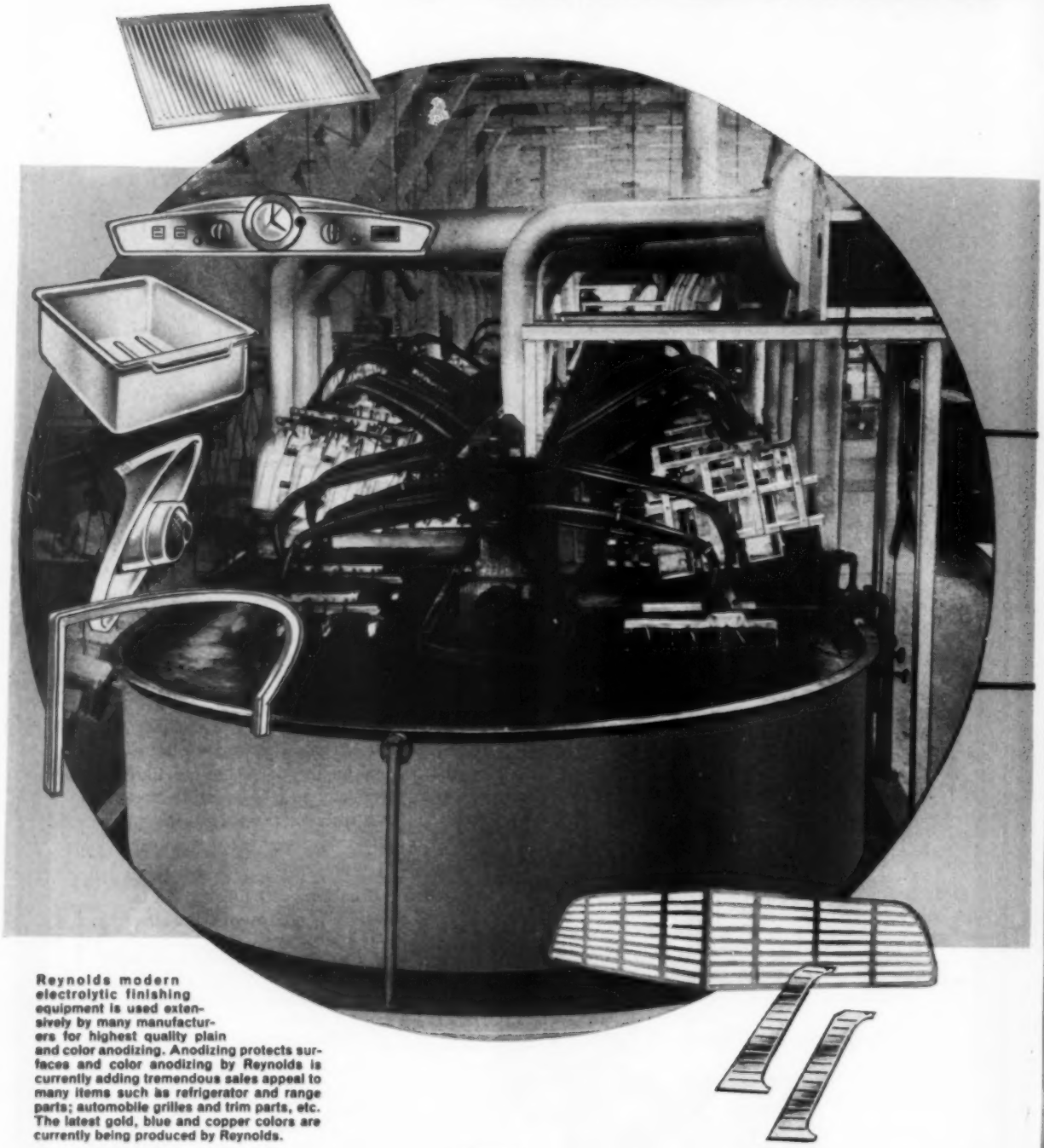
—manufacturers of SKF and HESS-BRIGHT® bearings.

—ITEM 248—

XUM

for finer "finished" aluminum products

FINISHES



Reynolds modern electrolytic finishing equipment is used extensively by many manufacturers for highest quality plain and color anodizing. Anodizing protects surfaces and color anodizing by Reynolds is currently adding tremendous sales appeal to many items such as refrigerator and range parts; automobile grilles and trim parts, etc. The latest gold, blue and copper colors are currently being produced by Reynolds.

REYNOLDS ALUMINUM

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING • FORMING • BRAZING

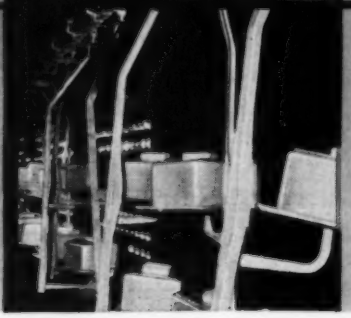
...greater design freedom, specify

from REYNOLDS

Mechanical • Chemical • Electrolytic • Paint Films

Buffing, here on deep well cookers, is one type of mechanical finish available from Reynolds. Scratch-brushing, satin finishing, highlighting, embossing and other finishes are also available.

Alodine system at Reynolds is adaptable to immersion, spray or brush type finishing. Etching, brightening and other chemical finish treatments are also available at Reynolds.



Reynolds can paint entire parts a solid color, mask and paint, or do paint filling in combination with mechanical finishing to supply practically any desired texture or highlighting effect.

The aluminum products you are designing now can be finished to meet your requirements by Reynolds Aluminum Fabricating Service—and here's why:

Reynolds existing extensive finishing facilities are currently being augmented by today's latest automatic finishing equipment. This tremendous investment by Reynolds offers you finishing facilities unsurpassed anywhere. It assures you finer finishes on the aluminum products you design. Gives you new flexibility in your design thinking. And—these new expanded facilities are backed up by Reynolds years of technical experience with practically every finishing process and technique applicable to aluminum . . . and by Reynolds famous quality control from mine to finished product.

For the highest quality from start to "finish," let Reynolds fabricate and finish your aluminum parts.

For full details on the many types of mechanical, chemical, electrolytic and paint film finishes that Reynolds offers and on the many other services offered by Reynolds, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or write *Reynolds Aluminum Fabricating Service, 2061 So. Ninth St., Louisville 1, Ky.*

Write for your free copy of the 24-page "Catalog of Facilities." Get full details on the tremendous production facilities of Reynolds Aluminum Fabricating Service.

See Reynolds New Program "Frontier" Sundays on NBC-TV.

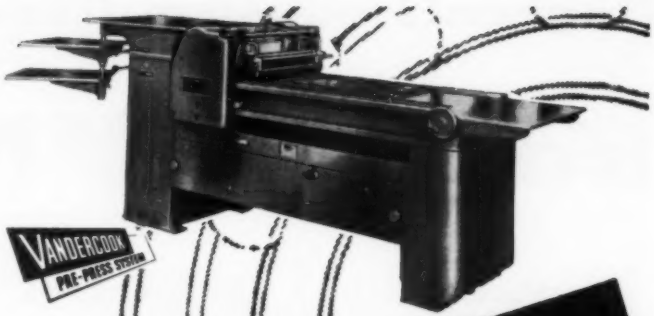
FABRICATING SERVICE

ROLL SHAPING • TUBE BENDING • WELDING • FINISHING • IMPACT EXTRUDING

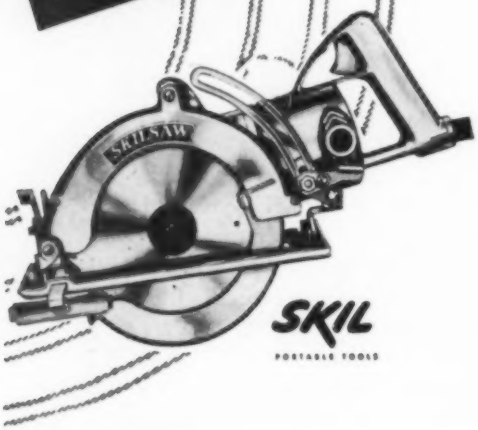
—ITEM 249—

XUM

Color printing demands exacting precision, vibration-free press performance for accurate register of one color to the next. You'll find Federal Bearings here, too.



in the workshop . . . or the print shop



High operating speeds . . . heavy, suddenly applied radial and thrust loads . . . little maintenance or none at all—they're all part of the service conditions Federal Ball Bearings meet in power hand tools.

so much of industry *turns* on FEDERAL ball bearings

In hobbyists' tools and home appliances—in pressrooms and mass-production plants—in farm equipment and business machines—you'll find Federal Ball Bearings quietly and efficiently at work, in some of the hundreds of types and 12,000 sizes that the company has been producing for almost 50 years devoted *only* to making ball bearings.

When Federal Ball Bearings are a part of so many things you *use*, shouldn't they be a part of the things you make?

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N. Y.

175 fact-packed pages of information on ball bearings are yours for the asking in Federal's Catalog. Just drop us a line for your copy.

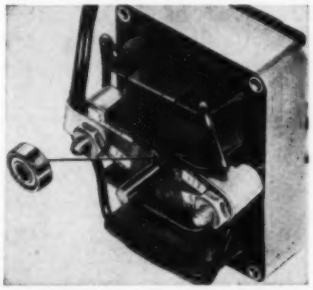
Federal BALL BEARINGS

One of America's Largest Ball Bearing Manufacturers

—ITEM 250—

For More Information Circle Item Number on Yellow Card—page 19

(Continued from Page 178)



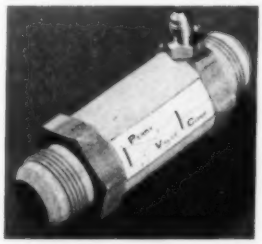
from 300 rpm to one revolution per week and in a variety of rated torques. **Gleason-Avery Inc.**, Auburn, N. Y.

—Circle ITEM 90

Shut-Off Valve

is pilot-pressure operated

Maximum working pressure of this AV-1000 pilot-operated shut-off valve is 3000 psi; pressure drop is 50 psi at 50-gpm flow rate. Incorporating one moving part, the valve is actuated by a pilot pressure that equals the working pres-



sure. Length is 5 in. and weight is 1 lb. Stainless-steel models are available on special order. **Perry Valve Corp.**, P. O. Box 132, Dover, N. J.

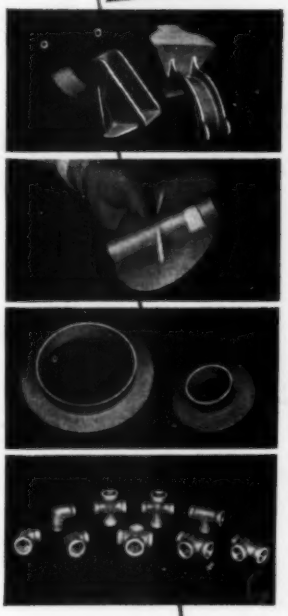
—Circle ITEM 91

Electronic Speed Control

for shunt-wound direct-current motors

Constant or continuously variable motor speeds are obtainable with this electronic speed control for shunt-wound dc motors. Designed for machine tool and other industrial control applications, it employs two full-wave thyratron rectifiers for supply and modulation of field and armature currents. In service where preset drive speeds are required, the control can be

look how ESCO SHELL CAST reduces your production costs



SAVINGS IN MACHINING COSTS — Most machining operations can be simplified or eliminated entirely.

SAVINGS IN MATERIAL — Shellcast parts can be poured to dimensional tolerances of plus or minus 0.010″ per inch. Sections less than 1/8″ can be Shellcast. Tremendous savings in material are made possible.

...IMPROVE YOUR PRODUCT DESIGN WITH ESCO SHELLCAST PARTS

SMOOTHER SURFACE — BETTER APPEARANCE — if desired, castings may be buffed to satin or bright finishes without prior machining. You get a better looking, more saleable product.

GOOD REPRODUCTION OF DETAIL — Shellcast often reproduces lettering so well that a separate nameplate is no longer needed. Intricate details of design, defying normal foundry methods, can be Shellcast successfully.

***ESCO* SHELLCAST IS A NEW CASTING TECHNIQUE** — that not only produces parts better, faster and at lower cost, but often makes substantial savings in basic production procedures. Smooth surfaces, with good reproduction of detail; uniform density, light weight . . . these are only a few Shellcast advantages that bring savings in materials, machine-finishing, and assembly. *ESCO* Shellcast is available in all low alloy steels, stainless steels and high alloys.

WRITE FOR FREE BOOKLET "CUT PRODUCTION COSTS WITH *ESCO* SHELLCAST"

ESCO ELECTRIC STEEL FOUNDRY CO.

2183 N. W. 25th AVENUE, PORTLAND, OREGON

( ) Send me a free copy of "Cut Production Costs With ESCO Shellcast".

( ) Have an application engineer call for an appointment.

Name_____

Company_____

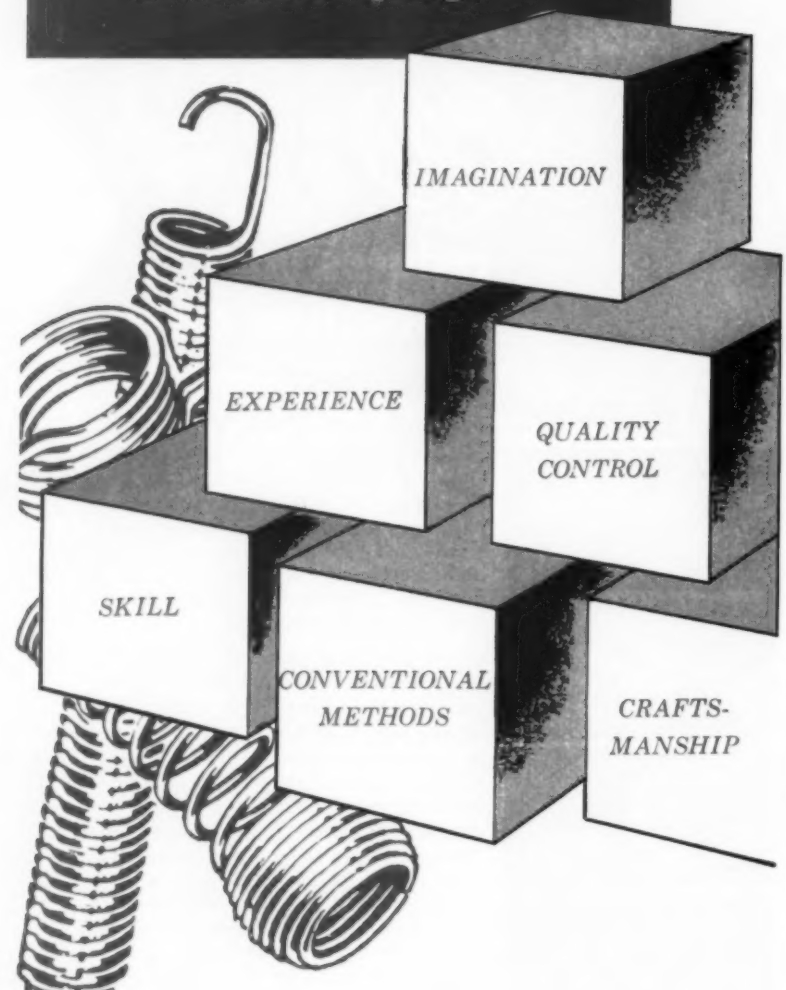
Address_____

City_____ State_____

—ITEM 251—

XUM

BUILDING BLOCKS
for Accurate Springs



Conventional, accepted standards of manufacturing springs are a building block at Accurate Springs. So are skill, craftsmanship, experience, quality control—*and imagination!* It all adds up to a better spring, at lower cost, held to closer tolerances—*for YOU.*

Accurate Springs

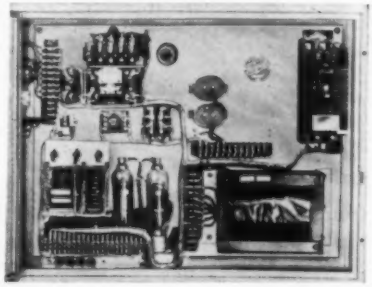
ACCURATE SPRING MFG. CO.
3824 West Lake Street
Chicago 24, Illinois

SPRINGS • WIREFORMS • STAMPINGS

—ITEM 252—
For More Information Circle Item Number on Yellow Card—page 19

New Parts

manually adjusted. Where speed must be continuously varied—to compensate for grinding wheel wear, for example—motor speed



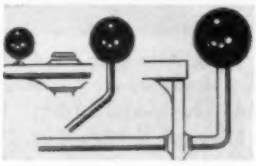
can be controlled by mechanical or electrical signals from auxiliary equipment. Unit is supplied as metal-clad switchgear for connections to 220/440-v ac lines. **Federal Pacific Electric Co.**, 50 Paris St., Newark 1, N. J.

—Circle ITEM 92

Plastic Balls

are tapped for use as lever knobs

Electrically and thermally insulating, these plastic balls are available in three stock diameters for use as lever knobs. Tapped steel inserts for either ½-in. or ⅝-in. levers are provided in the 2-in. diameter ball; 1⅝ in. and 1-in. balls



have a brass insert (⅜-in. tap) and a ¼-in. tapped hole, respectively. **Jergens Tool Specialty Co.**, 712 E. 163rd St., Cleveland 12, O.

—Circle ITEM 93

Snap-Action Switch

is dry-gas filled subminiature unit

Resistant to moisture, heat, cold and other environmental conditions that affect contact performance, series 6100 subminiature snap switch is gas-filled and hermetically sealed. Contacts are single-pole, double-throw; rating is 5 amp re-

JUST TRY IT!

..ask for a sample bar of La Salle's revolutionary

NEW fatigue-proof STEEL BAR

..the bar that has HIGH STRENGTH without heat treating

Yes, La Salle invites you to test a sample bar of the remarkable new FATIGUE-PROOF. This amazing new material is its own best recommendation . . . as proven by the many original equipment manufacturers who have already tested (and are using) FATIGUE-PROOF.

If you are making parts requiring strengths in the tensile range of 140,000 to 150,000 psi, and want to eliminate the expense or problems of heat treating . . . if you want to save production costs with a bar that machines faster (25% faster than annealed alloys—50% to 100% faster than heat treated alloys) and gives you a beautiful finish, too . . . if you want to improve the quality of your product while saving money, send us a blueprint, drop us a note giving application details, or better yet . . . pick up your telephone and call a La Salle sales engineer (REgent 4-7800, Chicago, Illinois).

If it appears that FATIGUE-PROOF can help you improve your product and cut your cost, he will arrange to provide the necessary test sample at no expense to you.

NEWLY PUBLISHED!

Get your copy of this 20-page booklet which gives detailed information on the remarkable new "FATIGUE-PROOF."

La Salle STEEL CO.

1426 150th STREET • HAMMOND, INDIANA

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars

Please send me your "FATIGUE-PROOF" Bulletin.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

—ITEM 253—

For More Information Circle Item Number on Yellow Card—page 19

XUM

ANOTHER UNUSUAL PROBLEM SOLVED BY LORD...

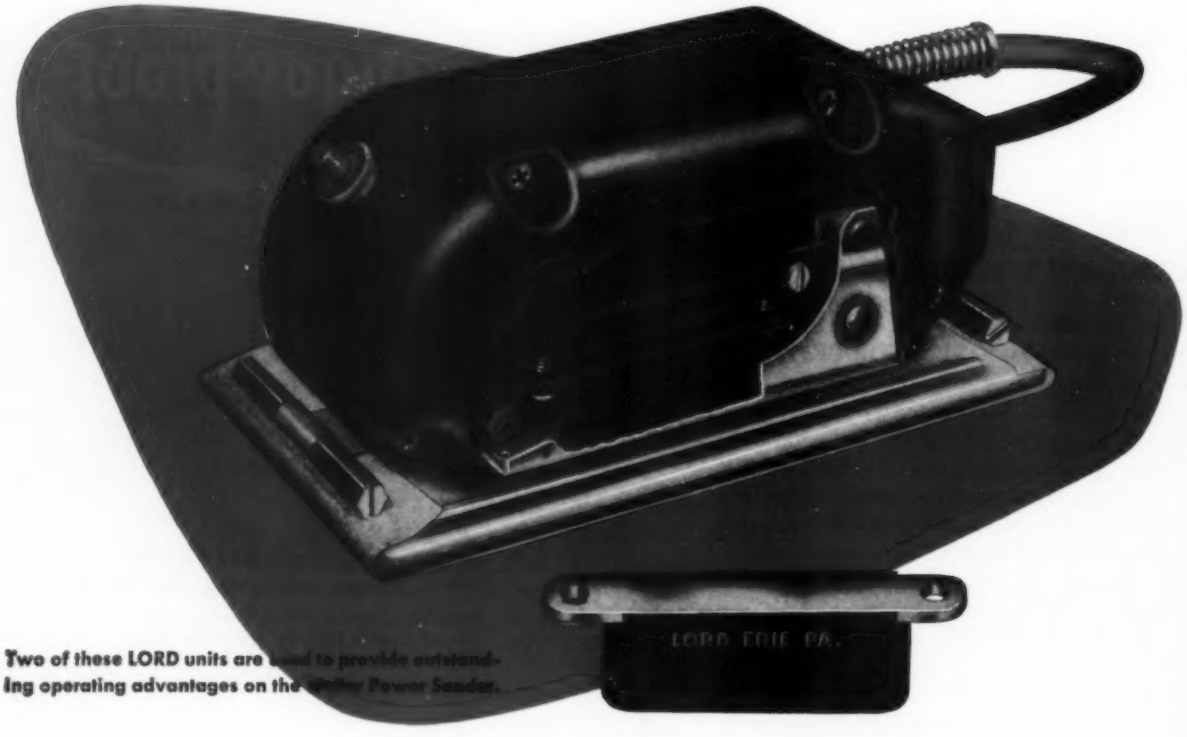
IMPROVED SANDING PERFORMANCE WITH LORD VIBRATION CONTROLS

The coordinated efforts of LORD development engineers and product engineers of the Weller Electric Company have resulted in several "built-in" performance advantages in the outstanding Weller Power Sander.

Lord Vibration Control units control the sanding plate action by (1) maintaining alignment of the plate to achieve straight-line motion, (2) eliminating vertical "bounce", and (3) transferring even pressure to all points of the sanding plate. In addition to these advantages, the flexibility of LORD units adds greatly to the service life of this sander by eliminating damaging rigid construction.

The LORD application on the Weller Sander is typical of many LORD contributions to better product performance through bonded-rubber vibration control units.

LORD is continually presenting new concepts in practical, efficient vibration control. Why not investigate the advantages LORD units will bring to your products? Simply contact the LORD Field Engineer nearest you or LORD MANUFACTURING COMPANY, ERIE, PENNSYLVANIA.



Two of these LORD units are used to provide outstanding operating advantages on the Weller Power Sander.

NEW YORK, N. Y. - Circle 7-3326 • PHILADELPHIA, PA. - LOcust 4-0147
CLEVELAND, OHIO - SUperior 1-3242 • DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060 • CHICAGO, ILL. - Michigan 2-6010
DALLAS, TEXAS - Riverside 3392 • LOS ANGELES, CAL. - HOllywood 4-7593
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

sistive, 3 amp inductive, 2 amp motor load. Switch meets MIL-S-6743 and MIL-E-5272. Housing is nickel silver; mounting arrangement is either bracket or through hole, and potted lead wires withstand 250 F. Series 6100 switch comes in several styles to meet user requirements. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn.

—Circle ITEM 94

Solenoid Valve

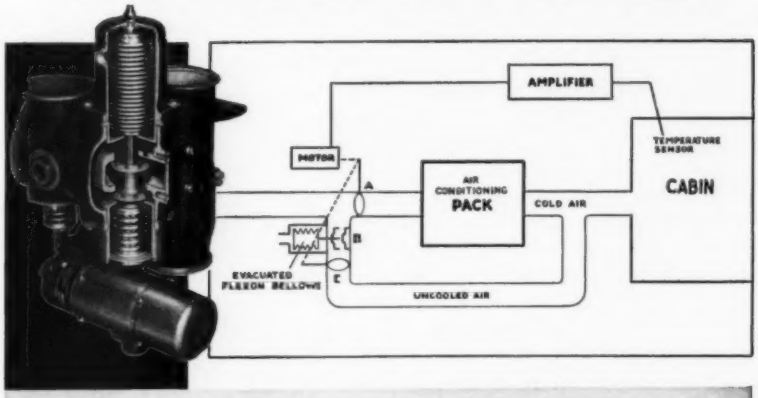
operates at pressures from 10 to 3000 psi

Two-way, pilot - operated, 1-in. stainless steel valve with packless construction is available with a standard coil for operation to 300 psi; with a high-pull coil for applications to 1500 psi; and with a double-wound coil and relay for pressures to 3000 psi. Full-ported construction permits maximum flow at maximum rated pressure. Valve piston rings are unbreakable. Coils are glass-wound silicone impregnated. Explosionproof housing is available. **Atkomatic Valve Co. Inc.**, 545 West Abbott St., Indianapolis, Ind.

—Circle ITEM 95

FLEXON® BELLOWS *Design Briefs*

Flexon® Bellows Governs Complex Air Conditioner Air Flow Valve

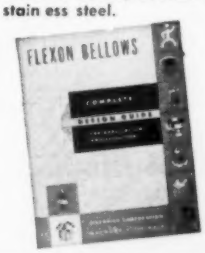


HOW IT WORKS

Valves A and C are connected by linkage and operated by an electric motor controlled by a temperature sensor to maintain a balanced flow of air through the conditioner and the by-pass. When Valve A opens, Valve C closes and vice versa. The Flexon Bellows actuates Valve B to regulate total air flow.

FLEXON® OFFERS THE COMPLETE BELLOWS SERVICE

Flexonics Corporation manufactures a complete range of bellows and bellows assemblies in brass, bronze or stain ess steel.



The Flexon Bellows Design Guide gives valuable application and design information. Write for your copy, today.

A Flexon Bellows is the heart of a mass flow valve manufactured by Stratos Division of Fairchild Engine and Airplane Corp., Long Island, N. Y.

Used in aircraft conditioning systems where upstream pressure varies over a wide range, the Stratos Mass Flow Valve is actually two valves in one body. Combining the features of a cabin temperature control valve and a conditioned flow regulator, its function is to maintain a constant flow of conditioned air to the aircraft cabin. Desired temperature is maintained by a balanced blending of cooled and uncooled air. The Flexon Bellows is used as an aneroid to maintain a constant volume of air regardless of atmospheric pressure. The schematic drawing above illustrates the operating principle.

The Flexon Bellows used in this valve design, like all Flexon Bellows, is cost engineered to meet the specific requirements of the job. To take advantage of this kind of service, send an outline of your requirements.

B-34

FLEXON® QUALITY
proved in service and backed by over 54 years manufacturing experience

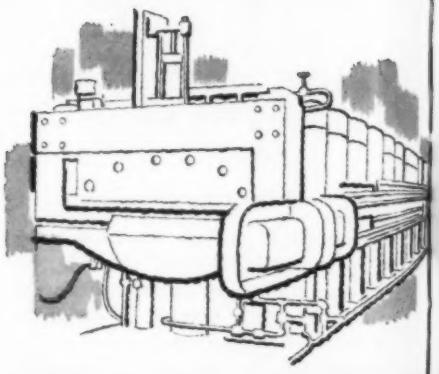
Flexonics *Corporation*
FLEXON BELLOWS DIVISION
1339 S. THIRD AVENUE, MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

—ITEM 255—

XUM

ELECTRICALLY CONTROLLED REELS SIMPLIFY HANDLING OF UNWIELDY RUBBER GOODS

Warner Electric Brakes and Clutches control take-up and let-off tension automatically!

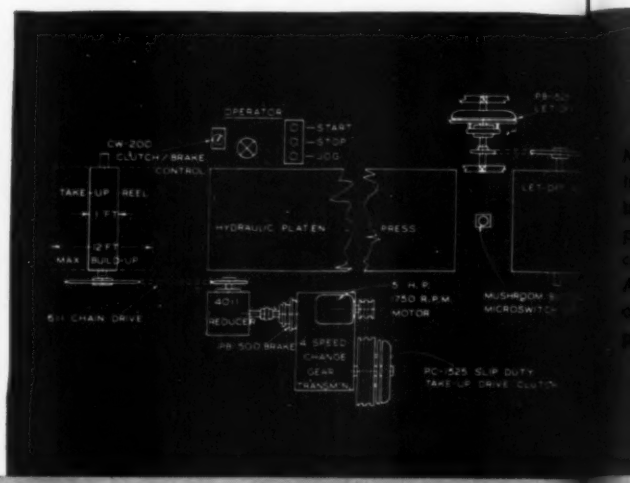


This reel tensioning application illustrates one of many *new ways* Warner Electric Brakes and Clutches easily solve a variety of complex machine control problems and make unusual production benefits possible.

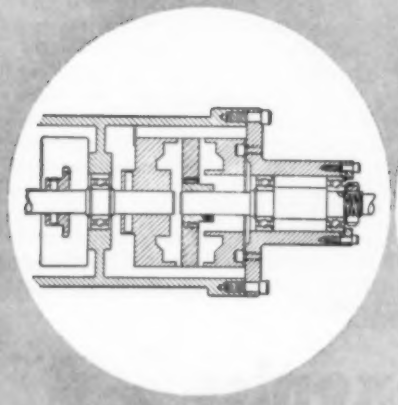
The problem is to maintain constant tension on rubber conveyor belting while reeling it off the platen press. Since the take-up reel builds up in diameter from 12 in. to 12 ft during the winding cycle, a four-speed transmission is used to vary the reel speed. To permit adjustment of the torque of the slip-clutch in relation to the reel speed, a manually controlled potentiometer was installed in the control panel. Thus, it is easy for the operator to modulate the torque and maintain constant tension at all stages of the operation.

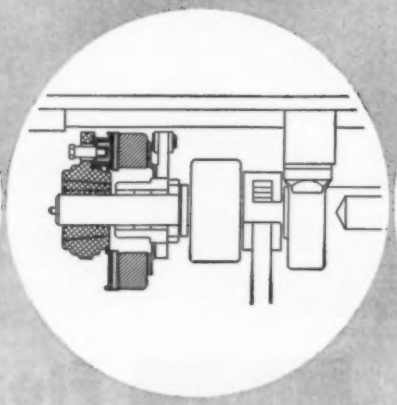
To prevent pile-up of material at the opposite end of the press, a Warner Electric Brake is installed on the let-off reel jack shaft. This brake is energized by a mushroom button micro-switch located directly below the belting. When the belt dips and contacts the switch, the brake is energized and remains engaged until excess slack has been taken up.

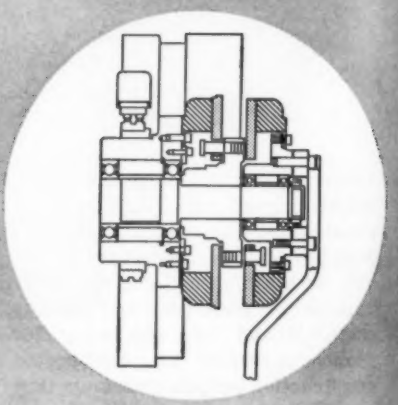
Other interesting examples of *electric motion control* are described and illustrated below.



EASILY SOLVE POWER PROBLEMS LIKE THESE







Surface Grinder

Cross feed is powered by constant speed a-c motor driving an electric clutch-brake. Armature keyed to cross feed shaft engages the clutch or brake which are alternately energized by a rheostat electronic timer. Cross feed increments can be adjusted down to .0005 in. Split-second starting and stopping is only one of the exclusive advantages of electric motion control.

Automatic Packager

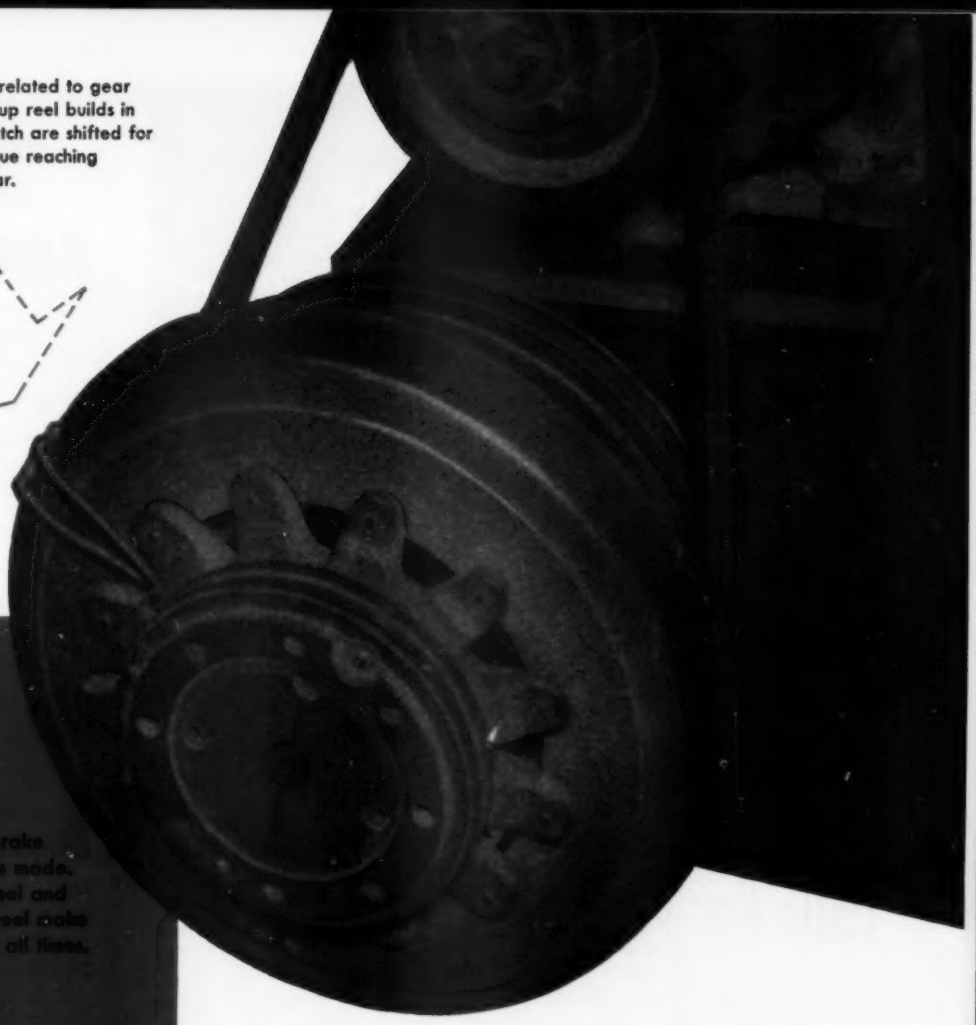
Armature is mounted on drive pins to hub, which is keyed to shaft controlling feed of paper roll. Magnet is bolted to stationary hub through which shaft revolves. Leads from magnet are connected to control panel and electric eye actuator. Actuator picks up registration marks on packaging material and controls brake which indexes feed roll for trimming.

Paper Cutter

Action selector permits continuous operation, one-revolution cycle, or jog. Clutch-brake controls operation of die head. Clutch and brake armatures are bolted to a special hub, keyed to drive shaft. Clutch magnet is bolted to free-running flywheel, on which collector rings also are mounted. Brake magnet is stationary-mounted to outboard bearing support.

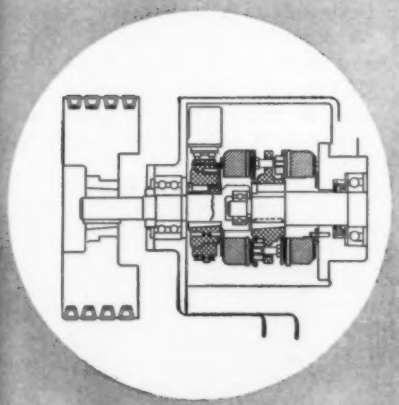
XUM

Drive clutch output is directly related to gear ratio of transmission. As take-up reel builds in diameter, transmission and clutch are shifted for slower speed and higher torque reaching maximum torque in fourth gear.



Mushroom button control prevents excessive build-up of material to be processed. Button actuates brake on let-off reel when contact is made. Automatic control of let-off reel and operator control of take-up reel make possible equalized tension at all times.

Warner Electric Slip Duty Clutch, above, is mounted on driven shaft of four-speed transmission. Clutch armature is mounted to free-running sheave—clutch magnet and collector ring assembly are keyed to driven shaft. Power is transmitted when clutch magnet is energized and "locks" with armature.



Index Table

Clutch-brake coupling controls indexing of master cam through worm drive. Clutch and brake armatures are mounted to opposite sides of hub keyed to driven shaft, end of which rotates freely in a pilot bearing on end of drive shaft. Clutch magnet and collector ring assembly are keyed to driving shaft. Brake magnet is stationary-mounted to housing.

WARNER

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Send for *new* 8-page condensed catalog showing complete line of Warner Electric Brakes and Clutches.

Name_____ Title_____

Company Name_____

Address_____

City_____ Zone_____ State_____

XUM

Top
QUALITY
CONTROL
calls for RECORDED EXACTNESS

Myriads of details go hand in hand with Quality Control. For one example, at the onset of production, a casting is "destroyed" by sectionalizing to determine dimensional accuracy. Irregularities can be corrected, molding methods acknowledged, and the general structure can be proved before subsequent costs are expended.

As illustrated above, the transparent "sectional template" visually approves interior members and voids, as well as outlines finish surface adequacy for the record.

Complete progress is recorded, and any time after inception —costs, revisions, equipment function, production details . . . and even difficulties encountered can be itemized with exactness.

It all adds up to *top quality control* service. This service can be *your* service. Write or call for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec.

Unitcast

QUALITY
STEEL
CASTINGS

ENGINEERING DEPARTMENT

EQUIPMENT

Cross-Section Template

for pen, pencil, or stylus drawing

Available in either 1-in. or ¾-in. scales this structural cross-section template has 43 sharply cut symbols of I-beams, broadflanged I-beams, channels and angles. Tem-

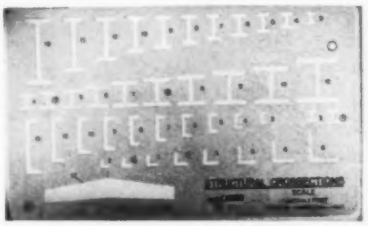


plate is 0.30-in. matte-finished vinyl and can be used with pen, pencil, or stylus. **A. Lawrence Karp**, 16 Putnam Park, Greenwich, Conn.

—Circle ITEM 96

Torsional Calibrator

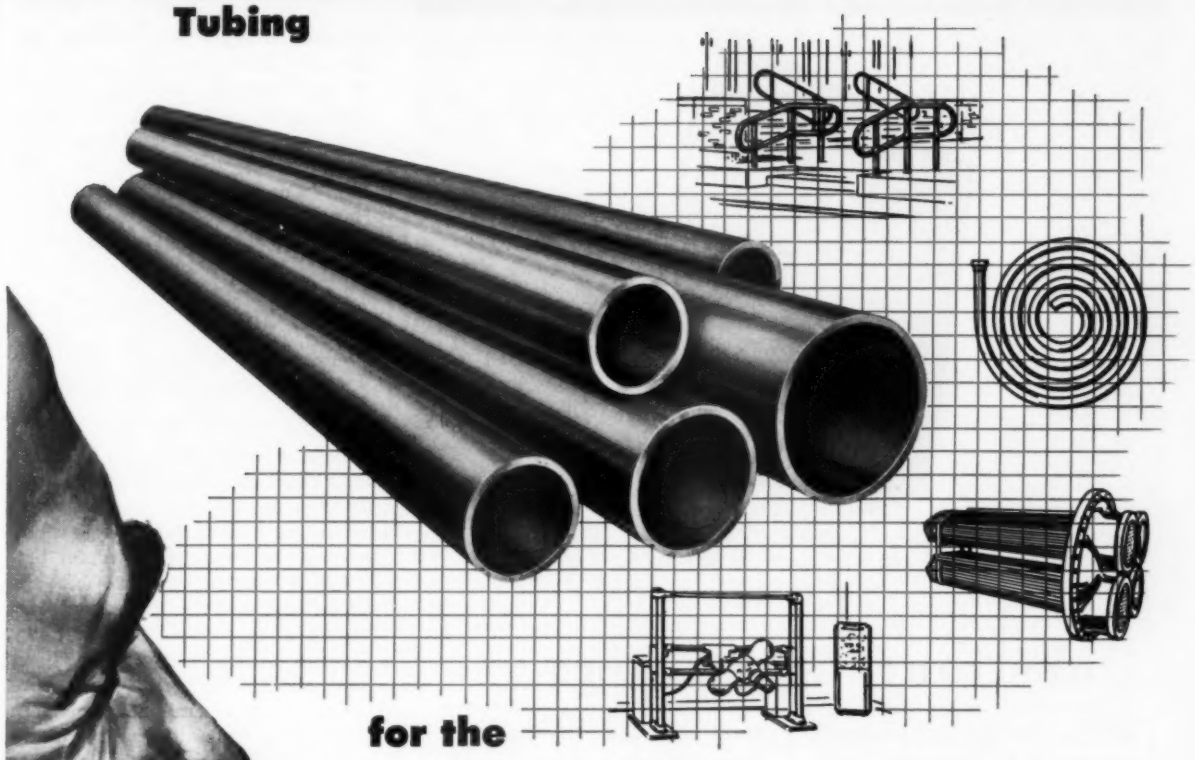
rated to 1600 cps at 100 lb-ft

Designed as a calibration device for torsional pickups, rate gyros, and similar instrumentation, model CA1050 torsional calibrator can also be used to excite torsional modes in a wide variety of small

rotating units. It is capable of producing torsional oscillations without resonance at frequencies to 1500 cps under free-table, no-load conditions. Maximum torque is 110 lb-ft, permitting no-load ro-

—ITEM 257—
For More Information Circle Item Number on Yellow Card—page 19

B&W Welded Stainless Tubing



for the

designer

...with a Critical Eye

The designer intent on developing a finer product at lower cost cannot afford to ignore the important design advantages inherent in B&W Stainless Welded Tubing:

- High strength-to-weight ratio
- Material, weight and space savings
- High resistance to corrosion and oxidation
- Ability to assume virtually any design shape without loss of structural advantages
- Improved product appearance
- Availability of a full range of types, grades, sizes and finishes to meet your requirements

Whatever your specific product requirements, B&W's wealth of experience in the manufacture of tubing for every type of application, assures you of Welded Stainless Tubing that is, in effect, custom-produced to your needs.

For help in choosing the *right tubing* for any specific job call in Mr. Tubes. He's your local representative of B&W's technical staff, regional sales offices, and a network of friendly tubing distributors. Take advantage of the extensive tubing knowledge he represents.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W STAINLESS and WELDED TUBES

TA-4059 (SWM)

XUM

FILTER FORUM

New publication by Purolator is the first comprehensive filtration guide ever edited specifically for designers

Question:

Where can a designer find all the answers to his filter problems?

Where can filters be used profitably? When should they be used? How do filters save money? What are the facts about degree of filtration, flow rate, contamination to be removed, viscosity of fluid? These are questions that continually come up in design work. But, up to now, no handy, authoritative source has been available for the designer's files.

Answer:

Purolator's new "Filtration Manual for Product Designers"

Now, for the first time, Purolator's new manual gathers all the answers in one place and makes them available to the product designer. "Filtration Manual for Product Designers" spells out application considerations in detail and includes a complete glossary of terms that apply to filtration. Here are some typical section headings:

	PAGE
WHY ARE FILTERS USED	4
WHERE FILTERS ARE USED	6
PLANNING FILTRATION IN ADVANCE	8
FILTRATION ENGINEERING	10
How filters are applied	10
Glossary of filtration terms	16
How Purolator filters are made	18
WHERE THE DESIGNER CAN SELECT A FILTER	22
Gasoline engine lubrication	23
Tank and crankcase breathers	23
Air intake for engines and compressors	23
Hydraulic fluid	24
Machine tool coolant	25
Bulk fuel handling	26
Diesel engine fuel	28
Diesel engine lubrication	28
Fuel oil burner	29
APPLICATIONS THAT CALL FOR SPECIALIZED STUDY	30

PUROLATOR

FIRST in the field of filtering

MAIL THIS COUPON FOR YOUR COPY

Dept. D7-38, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following:

_____ Copy of "Filtration Manual for Product Designers". I'm including 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

—ITEM 259—

Engineering Equipment

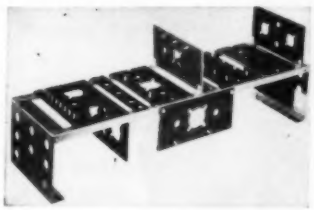
tational accelerations to 1570 rad per sec². Maximum displacement is 45 deg between mechanical stops. Diameter of calibrator table is 6 in., and stray flux density is less than 30 gauss on the table level. **MB Mfg. Co.,** 1060 State St., New Haven, Conn.

—Circle ITEM 97

Chassis Kit

contains components for prototype construction

Included in this low-cost chassis construction kit are: end brackets, side channels, terminal strips, miniature and octal tube socket plates, mounting boards, brackets, terminals, and screws. Intended for prototype construction, the kit employs high-quality components for electrical and mechanical stability. Overall sizes is 5 in. wide, 16⅞ in. long and 3½ in. high. Condensers, controls, and similar components are easily mounted through the holes provided in the chassis. For complex prototypes, two or more



kits can be joined together. For added versatility, provision is made for standard rack mounting. **Precision Metal Products Co.,** 41 Elm St., Stoneham 80, Mass.

—Circle ITEM 98

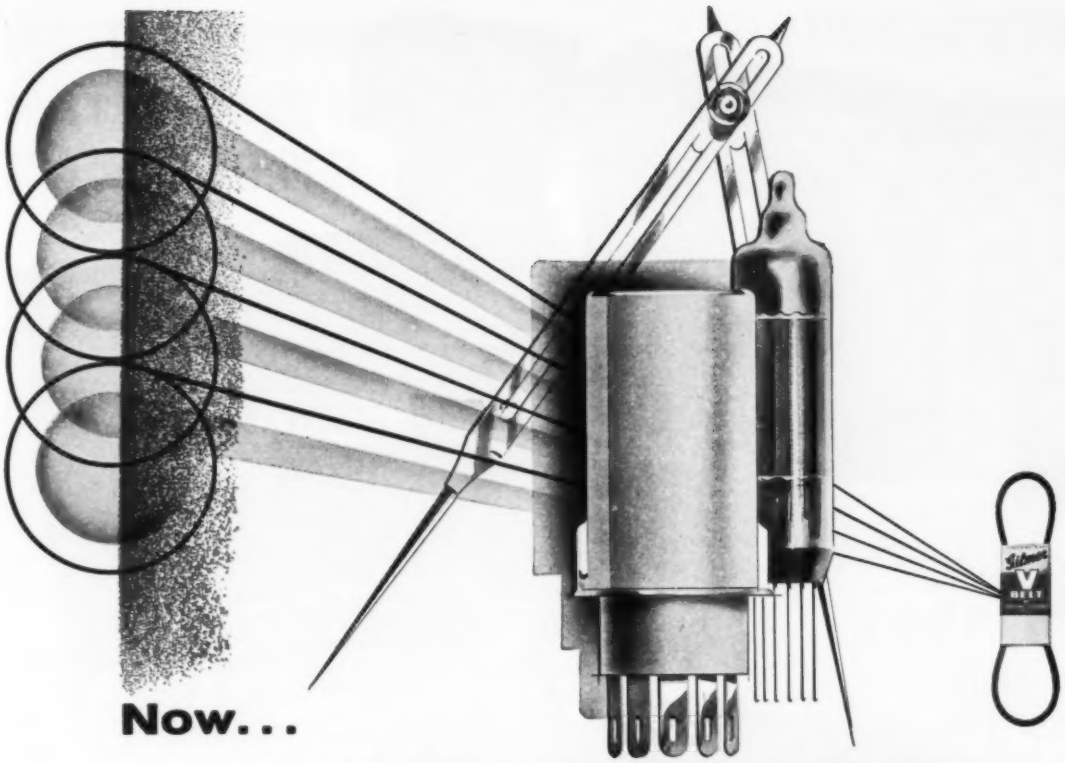
Green-Yellow Slide Rule

is easy to read

Noncorrosive light-alloy slide rule has green-yellow color that coincides with the optimum sight point of the spectrum, cutting eyestrain, blurring, and reading errors. Metal construction of the rule eliminates warping, swelling and binding. Standard 6-in. and 10-in. rules are available in trig and log-log scales. **Pickett & Eckel Inc.,** 1109 S. Fremont Ave., Alhambra, Calif.

—Circle ITEM 99

XUM



Now...

ELECTRONIC TENSIONING

latest development in the continuous perfecting of Gilmer V-BELTS

ELECTRONIC TENSIONING—brought to you by Gilmer—is today's biggest innovation in V-belt construction...your assurance of more dependable pulling power and longer service life!

In the manufacture of most V-belts, the cord section is wound with a *mechanical* device which attempts to regulate the tension. Gilmer V-Belts used to be made this way, too...until Gilmer engineers recently perfected a new kind of tensioning device regulated by error-proof *electronics!* This assures scientifically accurate distribution of the belt's load to every strand of its cord section.

Electronic Tensioning is the latest in a series of constant improvements in the construction of Gilmer V-Belts, many of which owe their origin to Gilmer's successful development of the "Timing" Belt. That is why you can be confident that the V-belts you buy today from your NYB&P-Gilmer Distributor embody the most advanced materials and manufacturing methods to give you maximum performance and service life.

V-BELTS AND "TIMING®" BELTS

NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — NEW YORK BELTING & PACKING CO. founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

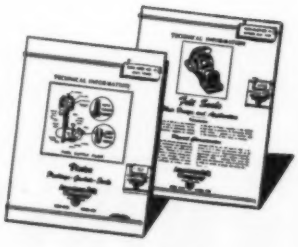
America's Oldest Manufacturer of Industrial Rubber Products

—ITEM 260—

XUM

The seals shown here are a combination of felt for shaft lubrication, plus spring-loaded leather or rubber for exclusion of water, fumes, dust. Such seals are made by a number of companies, in standard and special diameters. List of firms on request. Felt seals can also be made impervious by metal enclosures, or by the use of felt with one or more laminations of synthetic rubber. Just remember that felt is so versatile that it can either lubricate or seal, or both at the same time. On request we will collaborate on designs and specifications. Write for Data Sheet No. 11, "Felt Seals, Their Design and Application," and for No. 14, "Vistex, Packings, Gaskets, Seals."

American Felt Company
TRADE MARK ®

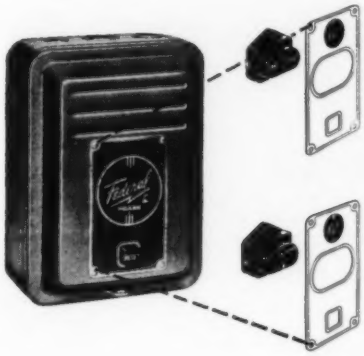


GENERAL OFFICES: 27 GLENVILLE ROAD, GLENVILLE, CONN.
SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S. C., Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

FREE! Write for Data Sheets Nos. 11 and 14.

—ITEM 261—
For More Information Circle Item Number on Yellow Card—page 19

FEDERAL PACIFIC adds new flexibility to MOTOR CONTROLS!



Three-way application with this single unit!

Convenient... simple... time conserving... the new Federal Pacific Motor Starter Conversion Kit literally permits triple duty performance from NEMA 1 enclosures size 0 through 3 —allows each to perform as either remote control (Form I), local control (Form II) or selector switch (Form III) motor starters!

SIMPLIFY INVENTORY—simply stock the basic starter plus Form II and Form III conversion kits and you can meet motor starter requirements up to NEMA size 3.

QUICK SIMPLE CONVERSION—no necessity to punch out or knock out holes to facilitate conversion. The facilities are designed into the unit.

COLOR CODED WIRING—color coding eliminates confusion... makes wiring a quick, simple operation.

Get triple duty performance in minutes
FIRST—Remove cover and add desired control block.
SECOND—Unscrew old nameplate and remove.
THIRD—Replace with new nameplate and the job is complete.

Finest Products Engineered

FEDERAL PACIFIC ELECTRIC COMPANY
50 Paris Street, Newark 1, N. J.

—ITEM 262—

THE ENGINEER'S Library

Recent Books

Principles of Nuclear Reactor Engineering. *By Samuel Glasstone;* 870 *pages,* 6 *by* 9 *inches, clothbound; published by D. Van Nostrand Co. Inc.,* 250 *Fourth Ave., New York* 3, *N. Y.; available from* MACHINE DESIGN, $7.95 *postpaid.*

This book is directed to practicing engineers concerned with the impact of nuclear energy on their professional activities and to engineering students at senior and graduate levels. The main purpose of the book is to describe fundamental principles. Accordingly, its scope is broad rather than deep. Chapters can be considered introductions to aspects of reactor design. They concern reactions and radiations, reactor steady state, disturbance of the steady state, instrumentation, control, fuels, construction materials, protection, shielding systems, thermal aspects, reactor design variables and descriptions. Publication of the book was recommended by the American Society for Engineering Education and authorized by the U. S. Atomic Energy Commission.

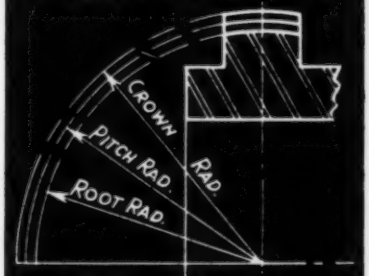
Principles of Farm Machinery. *By Roy Bainer, professor and chairman, Dept. of Agricultural Engineering, University of California; R. A. Kepner, associate professor of Agricultural Engineering, University of California; and E. L. Barger, Ferguson Div., Massey-Harris-Ferguson Inc.;* 571 *pages,* 5¼ *by* 8¼ *inches, clothbound; published by John Wiley & Sons Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.; available from* MACHINE DESIGN, $8.75 *postpaid.*

Designed primarily as a text, this book summarizes information useful to practicing agricultural engineers and others in the farm machinery industry. It deals with

(*Continued on Page* 198)

Here's the Big DIFFERENCE

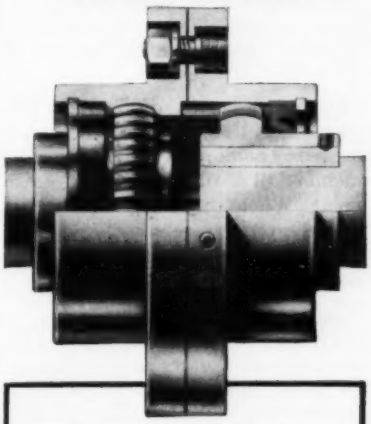
TEETH ARE CUT



ON A TRUE ARC

SPHEREFLEX®

COUPLING



SPHEREFLEX tooth design features an exclusive curved root and spherical tooth flank. Both angular and linear (parallel) misalignment are compensated for, since every portion of each gear tooth is actually a segment of a sphere. This special design eliminates all possibility of tooth interference and permits increased deflection between mating members. Full and uniform line contact, through the working depth of the tooth, insures a stronger coupling between driver and driven shafts; eliminates point rolling contact between gears during flexing; compensates for shaft misalignment up to 14° included angle. **Send for Catalog C-560**

PHILADELPHIA GEAR WORKS INCORPORATED
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA
BALTIMORE • CLEVELAND
Virginia Gear & Machine Corp., Lynchburg, Va.
Industrial Gears & Speed Reducers • LimiTorque Valve Controls
Established 1892

—ITEM 263—

(Advertisement)
ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .

Cylindrical Roller Bearing Inner Races

Their vital importance in bearing performance . . . advantages of carburizing . . . the manufacturing procedures which assure maximum quality and life

The function of an inner race is to provide a fatigue-resistant surface between a shaft and the rollers of an anti-friction bearing. Because of the geometry of a roller bearing, there is a smaller area of contact between the inner race and rollers than there is between the outer race and rollers.

This smaller area of contact has the effect of concentrating the loads on the inner race to a greater degree. Therefore, the inner race is always the critical member of a roller bearing from a fatigue life standpoint. When the inner race is the stationary member and the outer race rotates, this load concentration on the inner race is even more of a factor since the maximum load is repeatedly applied at one point.

Adequate resistance to relative movement between the inner race and shaft is vital to satisfactory performance. HYATT inner races are made of materials chosen to permit relatively heavy press fits. When HYATT press fitting recommendations are followed, the inner race becomes an integral part of the shaft for all practical purposes.

1. WHY CARBURIZING?

HYATT inner races are made of a good *carburizing* grade of steel, rather than through-hardened steel, for several reasons. First, carburizing permits the vital heavy press fits referred to above. Second, tough flanges that will not break out under impact can be obtained on carburized races with no loss of case hardness. Third, carburizing improves load-carrying capacity, as shown in Diagram A. During quenching, the phase change from austenite to martensite which occurs in the outer case is accompanied by a volumetric change; but the low carbon core remains tough and ductile *without* appreciable volumetric change. The result is a tendency to stretch the core and compress the case. Due to the Poisson effect, *the compressive hoop stresses in the external fibres build up the load-carrying capacity of the race.*

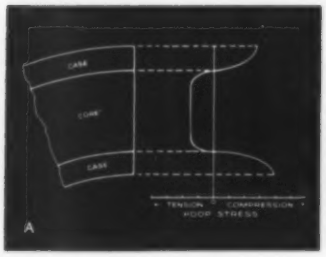
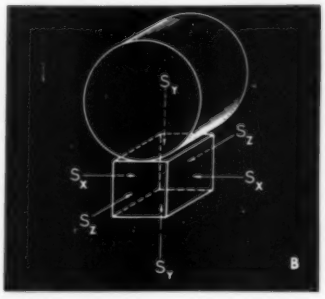


Diagram B shows a typical element of a HYATT carburized inner race under roller load. Stresses in the "Z" direction are negligible. Stresses in the "X" direction are compressive hoop stresses or preload. Stresses in the "Y" direction are compressive stresses due to the load. Without the compressive stress Sx (hoop stress) the load-carrying capacity would be less; and should the stress in the "X" direction become a tensile stress due to pressing a through-hardened race on a solid shaft, the capacity would be still further reduced. Reference to applicable theories of material failure will support this view and indicate why HYATT has gone to substantial added expense to give customers the benefits of carburized inner races.



2. OPERATIONAL REQUIREMENTS

A top-quality inner race should have all the following characteristics:

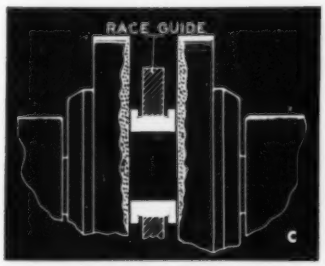
1. *Minimum wall variation:* Concentricity of the inner race pathway to bore is necessary for quiet operation at full bearing capacity.
2. *Minimum runout of race ends to bore:* The bearing must not be cocked on the shaft by location against a square shoulder with a race end having excessive runout.
3. *Minimum runout of race flange inner faces to bore:* Excessive flange face runout results in noisy operation and hunting of the shaft.
4. *Minimum bore tolerance:* An important fitting consideration. If all the available tolerance is taken in the race bore, the shaft tolerance is unnecessarily restrictive.
5. *Minimum pathway and bore taper:* Taper causes uneven roller loading with resultant overheating and poor life.

3. MANUFACTURING PROCEDURES

Good control of primary machining is reflected in good quality of the finished product. The early stages of manufacture, through the heat treating operation, are highly important and are all scrupulously controlled by HYATT. In this article, however, the *finishing operations* are of primary interest and will be discussed in detail.

Centerless grinding operation on a large Hyatt inner race.

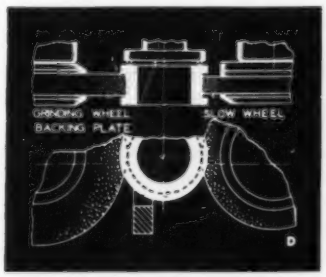
4. DOUBLE END GRIND



The sequence of grinding operations is important. The ends must first be faced off *square and parallel* so that during subsequent operations the ends can be used as accurate reference. The HYATT double end grind operation illustrated in Diagram C insures excellent control of race end parallelism.

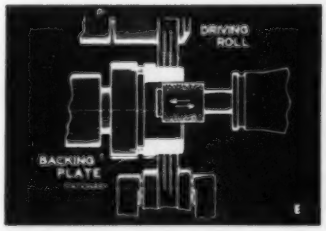
5. CENTERLESS PATHWAY GRIND

The centerless grinding principle was pioneered by HYATT many years ago. This method was a significant improvement over existing chucking methods because it eliminates excessive wall variation introduced by spindle and chucking errors.



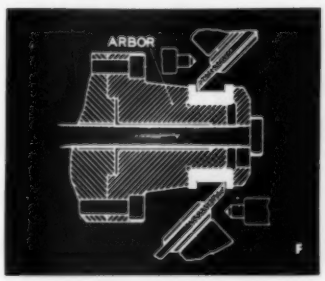
The race pathway is ground by the centerless method to produce a race with as nearly a perfectly round diameter as is commercially practical. Two-point and three-point out of round as well as taper are held to a minimum. Note that the work is rotated with a backing plate against the previously ground end, as shown in Diagram D.

6. CHUCKLESS BORE GRIND



Here again the centerless method is employed to generate an inner diameter (bore) concentric with the outer diameter (pathway.) This is accomplished by driving the race on the outer diameter and positioning the grinding wheel relative to the drive roll. The result is maintenance of minimum wall variation by removing stock from the high spots as they pass between the drive roll and the grinding wheel, as shown in Diagram E.

7. FLANGE GRINDING



All flange faces must be ground to run true with the roller pathway. Since the pathway and bore have been ground using the ends as a reference, the ends are also used as reference while grinding the flange faces (Diagram F). This establishes all-important even contact with the roller ends during operation of the bearing.

8. VIGILANT INSPECTION

Strict inspection is vital to the maintenance of high-quality standards in a precision product such as roller bearings. Working with the finest test equipment under conscientious supervision, highly trained HYATT inspection teams constantly watch the quality of HYATT parts as they are produced. This insures traditional HYATT dependability.

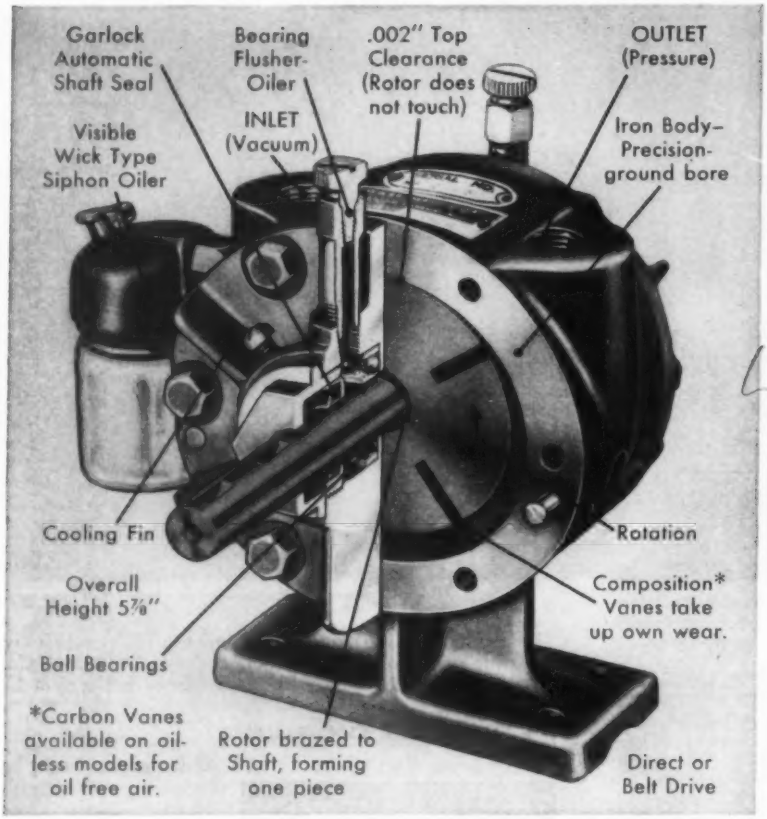
YOU WILL FIND FURTHER DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

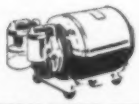
HYATT ROLLER BEARINGS

XUM

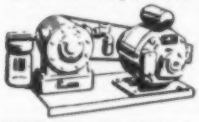

Garlock Automatic Shaft Seal
Bearing Flusher-Oiler
.002" Top Clearance (Rotor does not touch)
OUTLET (Pressure)
Visible Wick Type Siphon Oiler
INLET (Vacuum)
Iron Body–Precision-ground bore
Cooling Fin
Rotation
Overall Height 5⅞"
Composition* Vanes take up own wear.
Ball Bearings
*Carbon Vanes available on oil-less models for oil free air.
Rotor brazed to Shaft, forming one piece
Direct or Belt Drive

rotary vane

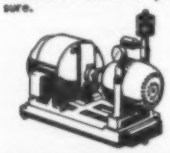
Quality and simplicity keep GAST AIR PUMPS operating for years at high efficiency levels



INTEGRAL-MOTOR PUMPS 1/12 to 1/3 H.P. .6 to 4 CFM. to 28" VAC., to 25 PSI.



LIGHT-DUTY PUMPS, V-belt or direct drive. 2 to 24 CFM. Moderate vacuum or pressure.



HEAVY-DUTY PUMPS, 1/4 to 1-1/2 H.P. 4 to 21 CFM. To 28" VAC. or 30 PSI. Cooling fans and fins.

As original components—or for special plant use—Gast Air Pumps offer important advantages. This cutaway reveals many reasons why they are specified as "original equipment" by more and more leading manufacturers.

All models are built to high quality-precision standards in a new, modern plant. All embody this inherently efficient, simple rotary-vane design. Balanced rotor is free of vibration. Sliding vanes are light in weight—for minimum motion-energy-friction loss compared to other pump designs. As vanes take up their own wear automatically, pump delivers full performance through years of use.

Get full details—write for *"Application Ideas" Booklet and Catalog.* Many sizes—*mention capacity and type that interests you!* Gast Manufacturing Corp., P. O. Box 117-P, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

—ITEM 265—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

(*Continued from Page* 195)

the common types of farm machines, emphasizing functional requirements and principles of operation. It includes discussions of materials, power transmission, economics, and methods for testing and evaluating performance.

•

Mechanisms, An International Bibliography. *Compiled and edited by Paul Grodzinski,* 41 *Tudor Close, Belsize Ave., London NW* 3, *England.*

The publication of *Mechanisms* is a new service for the field of mechanical design. The bibliography will list, index, classify and abstract the literature on mechanisms originating in all the most important industrial countries. It will cover electrical, electronic, hydraulic and pneumatic devices as well as items strictly mechanical. News and notes will be given on the first two pages. Sample pages of the new publication and information on subscription prices can be obtained from the editor of the bibliography.

New Codes and Standards

Square and Hexagon Bolts and Nuts, ASA B18.2-1955. 32 *pages,* 8½ *by* 11 *inches, paperbound; published by and available from the American Society of Mechanical Engineers,* 29 *West* 39th *St., New York* 18, *N. Y.;* $2.00 *per copy.*

This standard is a refinement of an earlier revision dated 1952. Inconsistencies in respect to fillets have been excluded from the 1955 edition and the length tolerances of heavy bolts have been improved. The standard covers square and hexagon-head bolts, regular and heavy, semifinished and finished, in slotted, thick, thick-slotted, castle and jam styles. Appendixes cover wrench openings, formulas and a thread runout sleeve gage.

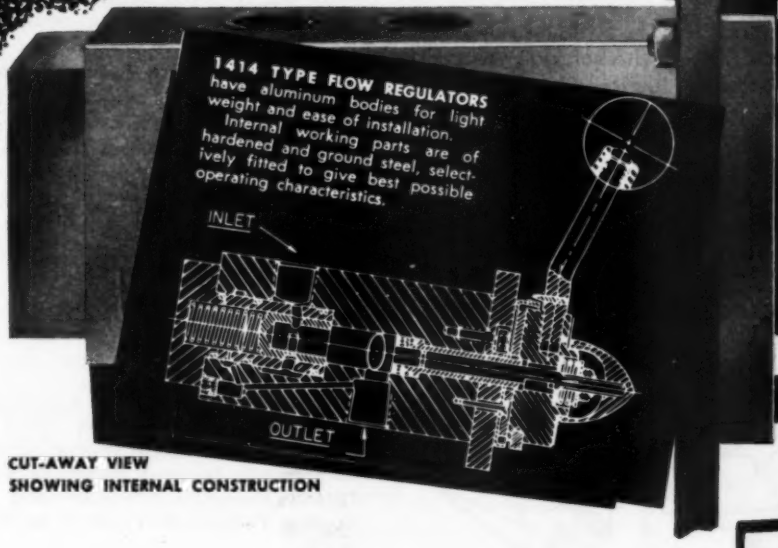
•

Safety Code for Elevators, Dumbwaiters, and Escalators. ASA A17.1-1955. 290 *pages,* 5¼ *by* 7¾ *inches; published by and available from the American Society of Mechanical En-*

ADJUSTABLE FLOW REGULATOR

Designed for Panel Mounting

LOOK TO WATERMAN FOR THE ANSWER TO YOUR FLOW CONTROL REQUIREMENTS


1414 TYPE FLOW REGULATORS have aluminum bodies for light weight and ease of installation. Internal working parts are of hardened and ground steel, selectively fitted to give best possible operating characteristics.
INLET
OUTLET

CUT-AWAY VIEW
SHOWING INTERNAL CONSTRUCTION

Waterman Engineering Company have combined in this new Adjustable Flow Regulator all the best, improved features . . . at the same time adapting it to Panel Mounting.

Increases the flexibility of your hydraulic system . . . ideal for installations requiring frequent changes in operating speeds.

Affords a variable adjustment of flow rate over a wide operating range.

Write for illustrated bulletin describing the many features of this Adjustable Flow Regulator such as right or left rotation of control handle, 180° handle rotation, pressure drop, regulated flow tolerance, etc.

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE EVANSTON, ILLINOIS

—ITEM 266—

XUM

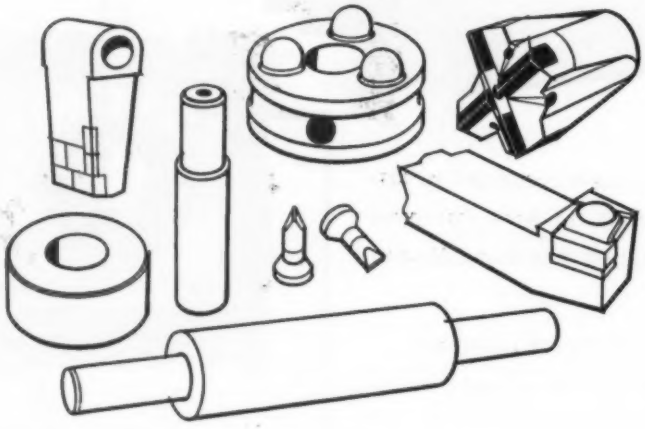
When compressive strength is important . . . look to KENNAMETAL*

The high compressive strength of Kennametal tungsten carbide compositions offers an unusual physical property to designers in that it is higher than that found in virtually all melted, cast or forged metals and alloys. It is as high as 800,000 psi.

In addition, Kennametal offers high hardness (85.0 to 93.0 Rockwell A); an extremely high Young's Modulus of Elasticity (as much as 94,300,000 psi); exceptional wear properties (as high as 100 to 1 as compared with steel); plus high impact strength and unusually high resistance to abrasion.

Where retention of compressive strength at high temperatures presents a problem, Kentanium* may be the solution. Kentanium titanium carbide compositions combine high compressive strength and resistance to oxidation and thermal shock at temperatures of 1800°F. and above.

With this combination of physical properties, Kennametal and Kentanium are providing unusual performance in such diverse applications as rolls for cold rolling of steel, dies, hammers and rams, mortars and pestles, testing machine parts (such as Brinell testing hammers), balls and seats for pumps, rock and core bits (for percussion drilling of hard rock and metal ores), milling and interrupted cutting of steels, hot rod-mill guides, and compression blocks for high temperature testing of alloys.



What is your problem? As Kennametal is made in many grades, each with a high compressive strength, you can select the right grade for a specific problem. Kennametal may be the answer in getting your idea from the drawing board into production. Why not discuss your problem with a Kennametal engineer? He can show you reports of Kennametal performance on scores of applications and help you apply the grade best suited for your purpose. For more information, write for Booklet B-111. KENNAMETAL INC., Dept. MS, Latrobe, Pa.

*Registered Trademark

A-9425B

INDUSTRY AND KENNAMETAL ...Partners in Progress

—ITEM 267—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

gineers, 29 W. 39th St., New York 18, N. Y.; $3.50 per copy paperbound, $4.00 per copy clothbound.

Sponsored jointly by the ASME, the American Institute of Architects and the National Bureau of Standards, this fifth revision incorporates engineering developments and safety agreements subsequent to the fourth edition of 1937. The code is intended to serve engineers and manufacturers of hoisting equipment as a basic reference of safety requirements. It is also intended for state and municipal authorities, and for owners and managers of structures in which the equipment is used. Seven new parts of the code concern hydraulic elevators; power and hand sidewalk elevators; lifts and elevators for private residences; inspections, tests and maintenance; alterations, repairs and replacements; design data, formulas and curves.

•

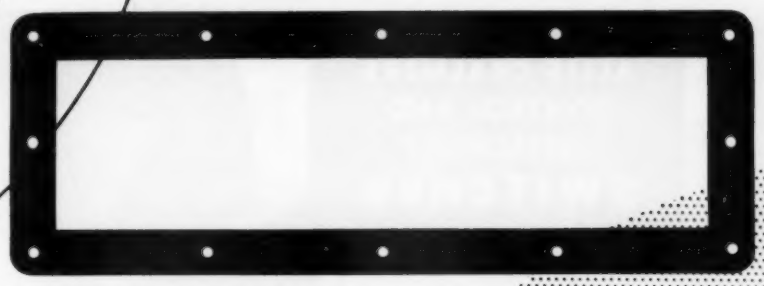
Small Solid Rivets, ASA B18.1-1955. *14 pages, 8½ by 11 inches, paperbound; published by and available from the American Society of Mechical Engineers, 29 West 39th St., New York 18, N. Y.; $1.00 per copy.*

This standard is the current revision of a 1953 edition having the same name and number. Specifications for chamfered points have been included in the newer revision. In addition to these data, the standard covers cooper's rivets, belt rivets, tinner's rivets and flat, countersunk, button, pan and truss head styles.

Association Publications

Proceedings of the RETMA Symposium of Automation. *114 pages, 8½ by 11 inches, paperbound; published by and available from Engineering Publishers, GPO Box 1151, New York 1, N. Y.; $5.00 per copy.*

The book includes the papers given at the Symposium in September, 1955, sponsored by the Engineering Dept. of the Radio-Electronics - Television Manufacturers Association. The contents are



New fiber gasket provides tight seal under high bolt loads . . . at temperatures up to 250°F

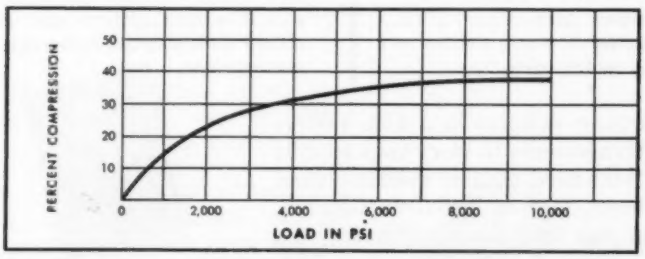
Armstrong Accopac® N-820—a new, beater-saturated fiber gasket material—is designed to handle sealing jobs where heat and pressure might cause ordinary plant fiber gaskets to fail. N-820, for example, is an economical replacement for sheet asbestos packing in applications where temperatures go up to 250° F—and bolt loads are 2000 psi and higher.

Here's why Accopac N-820 can do these jobs:

High density: N-820 is much denser than previously available fiber sheets. It withstands test pressures up to 100,000 psi without crushing. N-820 conforms well to flange surfaces, maintains torque much better than softer materials saturated by conventional methods.

Non-extractable binder: N-820 has no volatile binder which could be lost at temperatures up to 250° F. Its sealing properties are unaffected by the leaching action of contained fluids or by alternately wet-and-dry applications. Shrinkage due to binder loss is eliminated with N-820.

N-820 is the newest member of the Armstrong Accopac family, and it's already being used in many heavy-duty applications in place of more expensive materials. If you'd like more information about Accopac N-820, write for samples and data sheet to Armstrong Cork Company, 7003 Dean Street, Lancaster, Pennsylvania.



COMPRESSIBILITY. N-820, less compressible than other Accopac materials, is recommended for heavy-duty applications where flange pressures will be 2000 psi or more and where temperatures do not exceed 250° F.

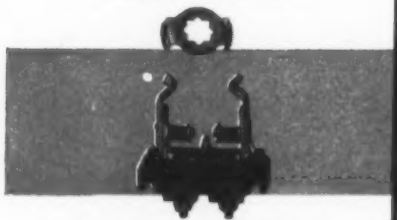
Armstrong ACCOPAC

. . . used wherever performance counts

ALLIS-CHALMERS CONTROL AND INSTRUMENT SWITCHES

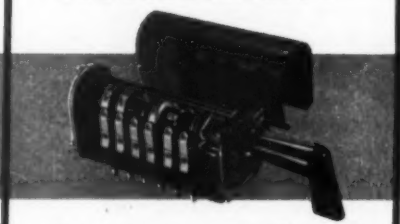
Mr. Panel Builder... here's what you should look for in control and instrument switches

FLEXIBILITY



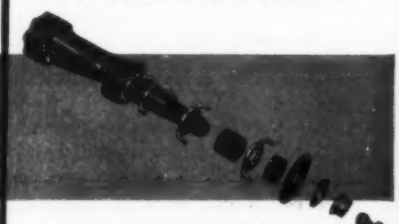
Each pair of stationary contact fingers is mounted individually. Unit construction facilitates adding stages and makes contact replacement easy.

ACCESSIBILITY

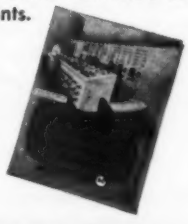


Snap-on cover can be lifted off —requires only a minimum space for removal. Arrangement of terminals permits wiring without removing switch cover.

DEPENDABILITY



Positive contact motion and definite contact position are made possible through the use of square shaft and star-holed contact segments.



Allis-Chalmers manufactures switches in a wide variety of types and contact arrangements to meet your specific requirements — with standard models available from stock. Write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletin 14B8112.

A-4952

ALLIS-CHALMERS

—ITEM 269—

For More Information Circle Item Number on Yellow Card—page 19

grouped under the headings: mechanization for high-volume assembly; data sensing, processing and utilization; the future of automation; automation for low-volume production; and redesign for automation of components and products.

Practical and theoretical considerations of techniques and systems are treated and economic problems are discussed. Design principles and application details are also presented. Specific items covered range from automatic production of components and electronic assemblies to automatic warehousing and automatic ticket reservation systems.

Manufacturers' Publications

Receiving Tube Manual. 336 *pages, 5⅝ by 8⅜ inches, paperbound; published by Radio Corp. of America; available from RCA tube distributors or Commericial Engineering Dept., RCA Tube Division, Harrison, N. J.; 60 cents per copy.*

Prepared for engineers and service technicians, this manual contains technical descriptions of RCA tubes used in standard broadcast, FM and television receivers. Preceding the descriptions are sections presenting electron tube theory, tube characteristics and applications. Other sections cover kinescope characteristics, tube testing, common circuits and tubes recently introduced.

♦

The Fabricator's Handbook. 162 *pages, 5⅝ by 8⅜ inches, paperbound; published by Crucible Steel Co. of America, Oliver Building, Pittsburgh 30, Pa.; available from the publisher on company letterhead request.*

This booklet offers general recommendations for the fabrication of parts in stainless steel by many of the common processes. Brief descriptions indicate the variety of stainless steels available and the range of processes by which the steels can be worked. Sections of the book concern forming, machining, cutting, joining, heat treating and pickling, finishing, and reference data.

A NEW tool for Spring Designers . . .

ALLOY'S 17-7 PH STAINLESS WIRE

17-7 PH Stainless Steel Wire gives you the spring characteristics of music wire plus these outstanding advantages:

a. Resistance to corrosion and oxidation
b. Low relaxation rate at temperatures up to 650F
c. High strength and modulus of elasticity
d. High torsional elastic limit

Alloy's 17-7 PH stainless steel spring wire is processed under rigid quality control standards to obtain optimum properties for spring fabrication. Full mechanical properties of the spring are developed by a single precipitation hardening heat treatment at 900F after fabrication. Because of its excellent dimensional stability, spring dimensions are unaffected by this heat treatment.

We can supply you with 17-7 PH wire in a wide range of sizes in coils or spools. Also available in rod and strip.

For complete information on properties, specifications and heat treatment techniques for Alloy's 17-7 PH stainless steel send for your copy of Technical Bulletin, T-1.

17-7 PH is a registered trade-mark of Armco Steel Corporation

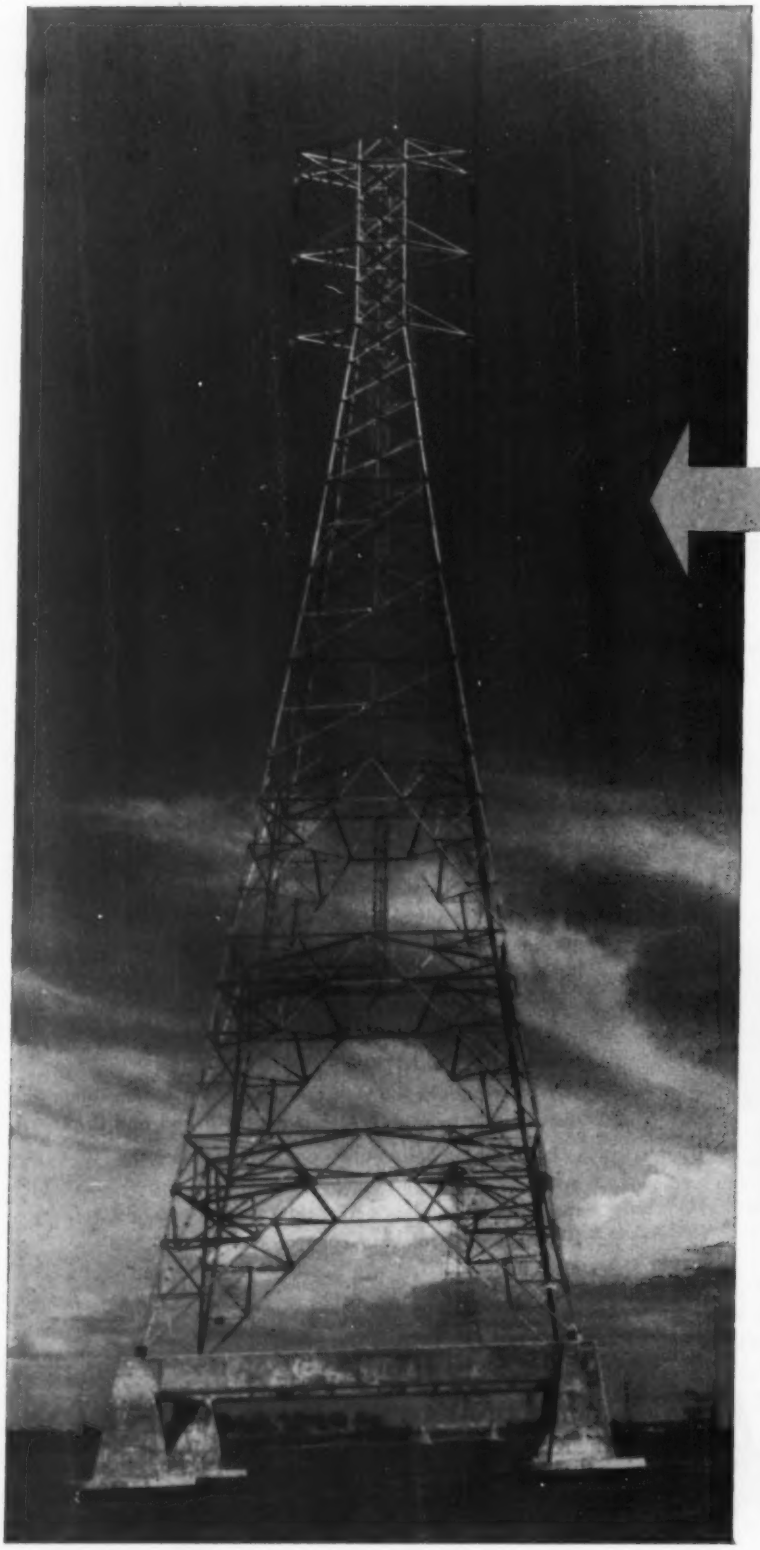
ALLOY HKP

ALLOY METAL WIRE DIVISION

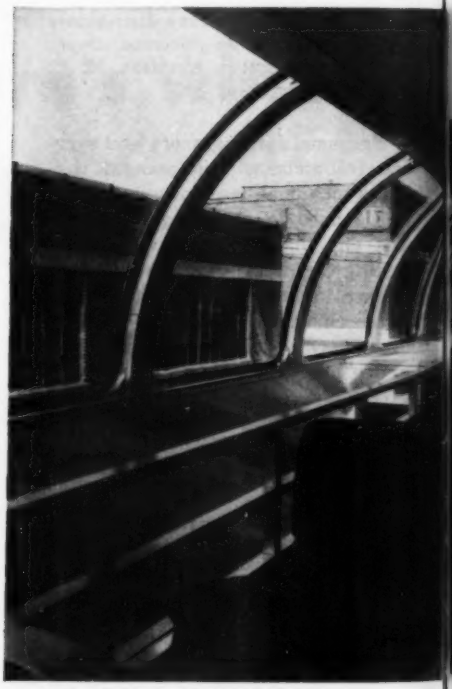
H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

—ITEM 270—

You can make it better

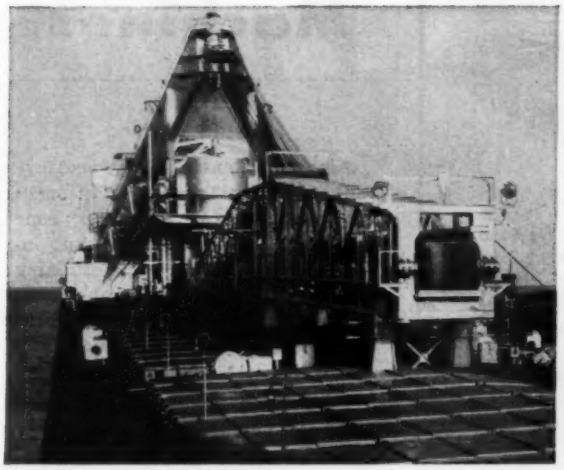


ERECTION COSTS REDUCED $7,200 by using USS MAN-TEN Steel rather than carbon steel in the legs of four 198 ft. transmission towers that carry power lines across Old Tampa Bay, Florida. Six tons of weight saved by MAN-TEN Steel in the East Bank tower saved $1,200 in erection cost. The 6½ tons saved in each of the three towers erected in the Bay saved $6,000 more. The total of 26 tons of steel saved by using MAN-TEN Steel also reduced the cost of the material used in the towers, even though MAN-TEN Steel costs a little more per lb. (Towers designed and fabricated by American Bridge Division of United States Steel for Florida Power Corporation, St. Petersburg, Fla. Erected by Southeastern Utilities Service Co., Miami, Fla.)



THE SUPERIOR STAMINA and corrosion resistance of USS COR-TEN Steel save power by saving weight, insure minimum maintenance and longer service life in this full-length "dome" lounge car built for the Milwaukee Road by Pullman-Standard Car Manufacturing Company, Chicago, Ill. More than 6,000 modern passenger cars and 190,000 freight cars of all types have been built to date with USS COR-TEN Steel.

with USS High Strength Steels



USED IN THE LOADING BOOM and supporting "A" frame of this self-unloading cargo vessel which can discharge 4,500 tons of limestone per hour, USS TRI-TEN "E" Steel not only materially increases the strength and durability of the structure but saves more than 18,000 lbs. of weight. 50,000 lbs. of TRI-TEN "E" Steel in plate and structural form were used in this application. (Designed by Robins Engineers, Division of Hewitt-Robins, Incorporated, for Manitowoc Shipbuilding, Incorporated.)

WEIGHT WAS REDUCED 10% yet strength-to-weight ratio was increased over former construction by using USS MAN-TEN Steel in the arch boom, "A" frame and tongue of this heavy-duty logging unit. The increased strength provided by MAN-TEN Steel makes it possible to handle log loads of maximum size—the reduced weight ensures greater mobility and maneuverability. Result: more footage, handled faster. (Designed and built by Hyster Company, Portland, Ore.)

IN USS HIGH STRENGTH STEELS, design engineers have at their command three service-tested steels that will permit them to materially increase the efficiency and economy of machinery, equipment and structures at little or no increase in first cost . . . and frequently, at a saving.

All three of these famous "steels that do more" – USS COR-TEN, USS MAN-TEN and USS TRI-TEN – have a 50% higher yield point than ordinary carbon steel. All have better corrosion resistance and offer greater resistance to wear, fatigue and impact. Each, however, has specific superior properties that should be considered in determining its selection.

USS COR-TEN Steel, for example, is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel. USS MAN-TEN Steel is intended for weight reduction by means of greater strength in moderate forming applications, with enhanced resistance to abrasion and atmospheric corrosion. USS TRI-TEN Steel's outstanding characteristics are excellent weldability and resistance to shock at low temperatures.

Used singly or in combination, these steels can advantageously replace carbon steel to increase the strength and durability of vital parts *without* increasing their weight. Or when the use of thinner sections is feasible they can (1) reduce equipment weight without reducing its strength, or (2) increase the size and capacity of equipment without increasing total weight or the power required to move it.

You will find our 174-page *"Design Manual for High Strength Steels"* extremely useful in applying the benefits of these steels to your product. Send for free copy—simply write on your company letterhead to United States Steel Corporation, Room 5198, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL · USS · HIGH STRENGTH STEELS · TWENTY-TWO YEARS OF PERFORMANCE

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

MECHANICAL ENGINEERS

with experience in design of:

- Precision Mechanisms
- Radar Antenna pedestals and mounts
- Lightweight Structural members.

The recent expansion of our engineering facilities makes it possible to offer unusual opportunities to experienced creative engineers.

Beginning salary range: $6000 to $10,000.

A brief resume form and a brochure describing our new laboratory may be obtained by writing to Mr. Robert E. Doherty.

At Raytheon's new Wayland Laboratory Mechanical and Electrical engineers work together as a team to create the custom designed equipment which has enhanced Raytheon's reputation for *"Excellence in Electronics"*.

RAYTHEON MANUFACTURING COMPANY

RAYTHEON

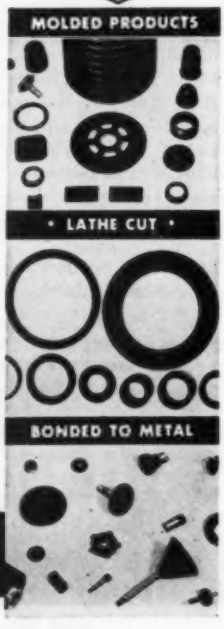
WAYLAND LABORATORY **WAYLAND, MASS.**

- *Full tuition paid for accepted educational programs.*
- *Location convenient for country or city living.*
- *Progressive salary review system.*
- *Liberal employee benefit program.*

—ITEM 272—

LET **GOSHEN RUBBER** *help you with* "APPLICATION-ENGINEERED" PRODUCTS *of* NATURAL SYNTHETIC *and* SILICONE RUBBERS

make GOSHEN *your* HEADQUARTERS *for*



Products by Goshen Rubber are not stocked, but are precision-fabricated to individual order. They're "application-engineered" to meet strictest specifications as to compound, service life and operating satisfaction. Inquiries regarding any rubber parts problem are invited.

SEND FOR NEW BROCHURE

This 8-page brochure and handy file folder tells how Goshen Rubber can help you. Send for your free copy today.

Over 40th year 1916 · 1956

See our "Facilities" catalog in Sweet's Product Design File.

Goshen Rubber Co. INC.

CUSTOM DEVELOPMENT AND FABRICATION SINCE 1916

1736 S. TENTH ST. GOSHEN, IND.

—ITEM 273—

New Machines

Air Conditioning

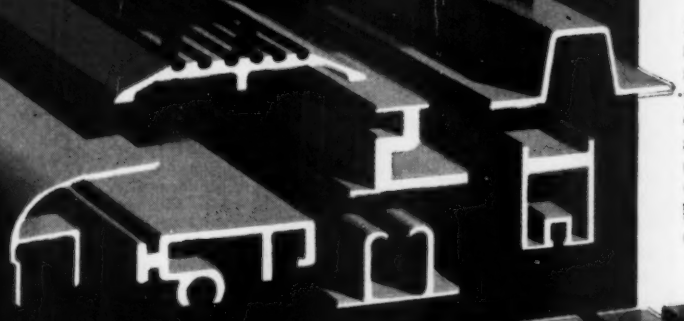
Air Conditioners: High-pressure Induction UniTrane conditioners are designed for perimeter zone cooling and heating in an induction type air conditioning system. Tandem jet arrangement in the nozzle plate permits induction of a large amount of secondary air, which is blended with primary air before discharge. Air is filtered through standard 1-in. disposable filters as it enters the conditioner. Available in a vertical cabinet and vertical concealed models, the units have eight basic capacities from 30 to 120 cfm of primary air. Smooth plastic nozzles, available in standard or oversize types, are contoured to minimize noise level and to prevent the collection of dirt and dust. Controls for temperature selection are easily accessible. *The Trane Co., La Crosse, Wis.*

Room Conditioners: Flow-Temp units are available in capacities of 200, 400 and 600 cfm. The conditioners perform heating and cooling, dehumidification, fresh air ventilation, filtering and circulation operations. Four-speed fan control and either automatic or manual hot and cold water controls regulate room temperature. Remote control is possible. Low-speed blowers, spun glass insulation and heavy-duty steel cabinets provide quiet operation. Models for ceiling, wall or free-standing floor installations are available. *Acme Industries Inc., Jackson, Mich.*

Domestic

Electric Cultivators: Models 143 and 144 cultivators can be used to hoe, mulch and aerate soil, blend in fertilizers, and remove weeds. Cultivating tines move rapidly in an orbital path to mulch the soil. Model 144, which has a 4-in. diam tine plate, cultivates at 2350 rpm in a 3/16-in. orbit; model 143, with 26-in. plate, cultivates at 2650 rpm

REVERE



It is Revere's business to supply you with metals that can keep your production flowing smoothly. In Revere Aluminum Extrusions you get metals made with a skill that comes only from many years' experience, plus service and delivery that come from Revere's undivided interest in filling your needs. It will pay you to gear the progress of your business to the most dependable sources of supply.

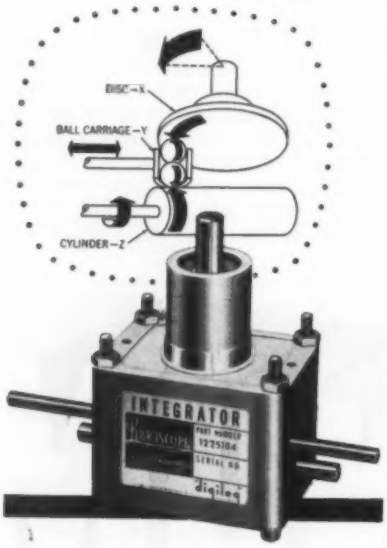
ALUMINUM

Revere Aluminum Mill Products include extruded products; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn tube and welded tube; rolled shapes; electrical conductors; forgings; and foil. Call the nearest Revere Sales Office now. They are in all principal cities. Revere Copper and Brass Incorporated. *Founded by Paul Revere in 1801.* Executive Offices: 230 Park Avenue, New York 17, N. Y.

EXTRUSIONS

XUM

Primary parts of the Librascope Ball and Disc Integrator are a rotating input disc (X), two counter-rotating steel balls enclosed in a carriage (Y), and an output cylinder (Z). The cylinder speed is proportional to the product of the disc speed and the ball carriage position. The disc speed and ball carriage position can be continuously variable.



LIBRASCOPE

BALL and DISC INTEGRATOR

A precise, instrument-size mechanical integrating element or variable speed drive

Useful as a mathematical tool for speed multiplying, speed ratio computing and flow rate totalizing. Also fire control and automatic feedback applications.

Size	1⅞"x2¾"x3¼"
Weight	17 oz.
Starting torque, no load	2 in. oz.
Output torque	2 in. oz. max.
Carriage travel	±¾" from zero
Output ratio	2.4:1
Precision	As high as 0.01% at stated output torque

Write for Catalog

LIBRASCOPE

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

808 WESTERN AVENUE • GLENDALE, CALIFORNIA

—ITEM 275—

New Machines

with a ¼-in. orbit. Both machines are driven by an ac-dc motor. Toggle switch provides instant, positive power control. The cultivators are 54 in. long and are balanced and lightweight. *Porter-Cable Machine Co., Syracuse, N. Y.*

Photometer: Model 1370 Servotherm UV-IR portable meter corrects meter errors caused by temperature changes, fixed field of view and low sensitivity. It also extends spectral coverage into infrared and ultraviolet and is applicable to color separation and analysis problems. The meter is designed to measure accurately radiation in selected spectral bands corresponding to specific film types. It covers a range from 0.3 to 3.0 mu, ultraviolet, visible and infrared. Selective fields of view from 7 to 50 deg permit distant measurement of an entire picture or of specific highlights. The unit is powered by six miniature batteries. Operating at any altitude, it is independent of ambient temperature variations and can be mounted on either tripod or hand grip. Shutter speed scale range is 1/1600 to 1 second; f stop scale range, f/1.5 to f/64. *Servo Corp. of America, New Hyde Park, L. I., N. Y.*

Metalworking

Bar Bender: Bending unit is designed for rapid bending of workpieces such as concrete reinforcing bars, stirrup bars and tie bars, as well as for forming smooth rounds, squares, and deformed bar stock of all types. The machine accommodates up to two 1¼-in. diam steel bars or eight ½-in. diam bars simultaneously. Speed and angle of bend can be adjusted for slower operation. The unit is hydraulically powered and is self-contained, including oil reservoir, pump and motor. Floor space requirement is 35 x 66 in. *Pines Engineering Co. Inc., Aurora, Ill.*

Punch Press: Electro-Safe 15-ton press has safety features such as elimination of the flywheel and absence of standard clutching operation. Operator must use both hands at the same time to push buttons which operate the machine. The press is equipped with a heavy-duty safety brake which applies when power is disconnected or dis-

Endurance Rated
ELECTRIC COUNTERS and ACTUATORS
to Fit every need

200,000,000 COUNT LIFE

PIC SUPER-WIZARD

1000 CPM.
5 watts input.
Balanced Armatures.
4 and 6-digit models in basemount, panelmount and dustproof enclosed types for 60, 40-50, 25 cycles and DC; all voltages to 230.
Purchase cost only 18c per million counts.

50,000,000 COUNT LIFE

PIC 600

1000 counts per minute
7 watts power consumption
Balanced armature
Quiet operation. No AC hum.
Tamper proof housing.
Lubrication not required.
Available in basemount and panelmount models—also to count dozens, for 60, 40-50, 25 cycles and DC; all voltages to 150.

6,000,000 COUNT LIFE

PIC MERCURY
4-digit Reset

600 Counts per minute.
3 watts power input.
4-digit Basemount and Panelmount models also to count dozens — all voltages to 115, AC or DC.

3,000,000 COUNT LIFE

PIC MERCURY
5-digit non-reset

600 Counts per minute.
3 watts power input.
Tamper proof construction.

See your PIC Representative or write

PIC PRODUCTION INSTRUMENT CO.

702-08 W. Jackson Chicago 6, Illinois

—ITEM 276—

How to Keep Blood From Freezing

No. 1 of a series — *Showing the broad application range of Fenwal Controls*

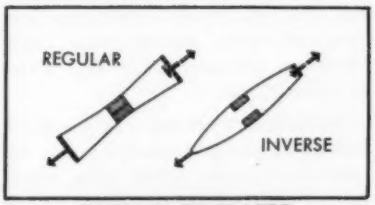
The problem was one of providing warning if blood under refrigeration was subjected to temperatures below 32°F or above 48°F. Here's how Fenwal Thermoswitch units solved it.

Fenwal Thermoswitch units were connected in parallel series. The regular type #17000, which opens on temperature rise, closes when the temperature falls to its setting of 32°F. The inverse type Fenwal Thermoswitch unit, which closes on temperature rise, closes when the temperature rises to its setting of 48°F. Between 32°F and 48°F, both Thermoswitch units are open so that no alarm is given.

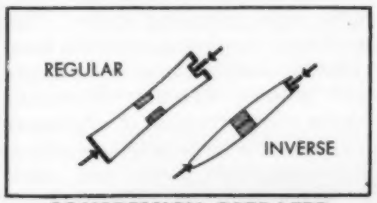
How Fenwal Thermoswitch® Units Operate

In Thermoswitch thermostats the activating *control* element is the metal shell which encases the contact elements. Changes in temperature cause the shell to expand or contract instantaneously. This exerts either tension or compression on the struts, causing the contacts to make or break a circuit. Control in the Fenwal Thermoswitch units is calibrated at a given shell temperature by turning the adjusting screw until contacts operate.

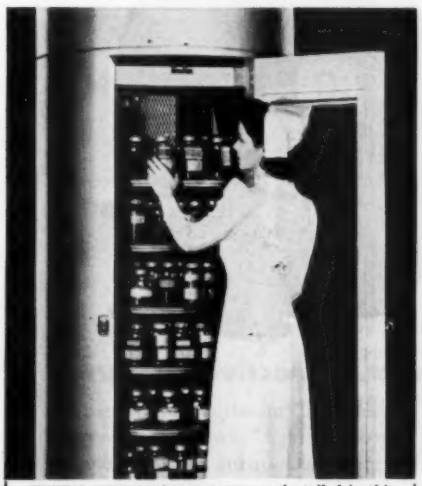
Fenwal Thermoswitch Controls are constructed as either tension or compression operated with regular or inverse contact arrangements.



TENSION OPERATED

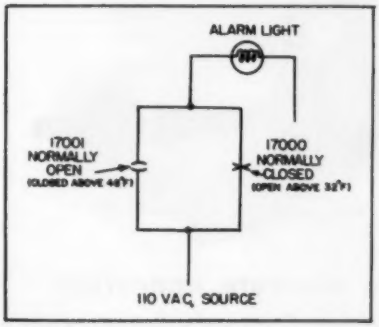


COMPRESSION OPERATED



FENWAL THERMOSWITCH UNITS are installed in this blood bank to prevent blood from freezing. Compact Fenwal units are easily adjustable, highly resistant to shock and vibration and are totally enclosed against dust and dirt.

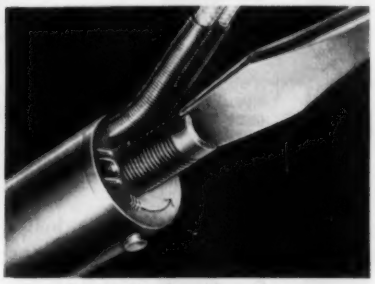
Tension operated units may be subjected to momentary temperature exposure of 100°F above their set point. They also may be subjected to any temperature below their set



point without danger. Tension operated Fenwal Thermoswitch units may be set below 0°F but compression operated units are recommended if rapid temperature changes in excess of 100°F or extreme temperature overshoots are to be encountered.

The Fenwal Thermoswitch Control is constructed with two silver contacts mounted on, but electrically insulated from, curved nickel-iron struts of low expansion coefficient. This element assembly is then mounted under tension or compression in a seamless drawn brass or stainless steel tube. The amount of tension or compression is variable, depending on the position of the adjusting sleeve and the temperature of the shell.

Fenwal compression operated units may be exposed to a temperature of −100°F indefinitely, and to temperatures 400°F above their set temperatures for short periods of time.



Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal Thermoswitch units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers.

Write for new Catalog No. 500 for details and complete product listings on Fenwal Thermoswitch Thermal Controls, including units discussed above, Midget and Miniature versions of these, Snap-Action Controls, and Indicator Controllers.

FENWAL INCORPORATED
193 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is:.....

.....

.....

Name.....*Title*.....

Address.....

City.....*Zone*...*State*.....

Fenwal CONTROLS TEMPERATURES . . . *PRECISELY*

REEVES

the right speed for every need!

fractional HP Vari-Speed

MOTODRIVE

compact, attractive design

Within streamlined, metallic blue housing is REEVES' "weatherized" motor, time-tested speed changing mechanism, and heat-treated helical gear speed reducer. Maximum space for vertical model only 16⅛" x 21½" x 11½". Other models equally compact.

simple, accurate operation

14-turn handwheel on Speedial indicator gives you stepless, accurate speeds from 3 to 4660 rpm's—within a 2:1 to 10:1 speed range. Electric remote or automatic controls also available.

45° Model

Horizontal Model

versatile application

Select your *exact* needs from 112 assemblies: ¼, ½ or ¾ hp. units; horizontal left or right, vertical, or 45° left or right models; horizontal or vertical down output shaft.

Write Dept. H19d-M543 for complete bulletin.

REEVES PULLEY COMPANY • Columbus, Indiana
Division of RELIANCE Electric and Engineering Co.

New Machines

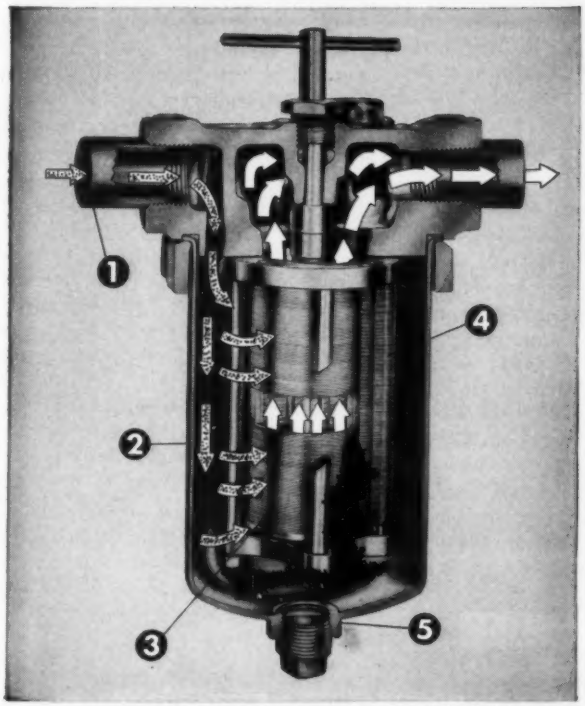
rupted. Safety stop button stops the machine instantaneously at any point in the cycle. When set for single stroke, the press starts from a standstill, completes its stroke without clutching, and is inoperative until another stroke is initiated. Electrical selector switch permits setting the press for continuous stroke, single trip and inching. The machine single-strokes to 60 times per minute. Recommended continuous operating speeds obtained by changing the ratio of the motor speed to the final drive, range from 20 to 200 strokes per minute. *Kenco Mfg. Co., Los Angeles.*

Spot Welder: Bren/Weld SP-100 automatic welder can weld 18-gage steel at a rate of 100 spots per minute, and lighter gages as fast as they can be fed. The unit will weld two pieces of ⅛-in. steel. It is equipped with a transformer having a power factor of 70 per cent. Welder design incorporates repeat, nonbeat operation, NEMA type 1AX timer, welded, structural steel frame enclosed in a heavy-gage steel case, double-acting air cylinder with adjustable speed control in both directions, and welding horns which can be moved in and out and rotated 360 deg. Controls are mounted on a side panel. Self-compensating pressure switch eliminates adjustments when air pressure is changed. The unit has radial windings for good ventilation and long life. Primary windings are insulated with double glass over Formvar. *Brennen, Bucci and Weber, New York.*

Guillotine Cutters: Redesigned line of high-speed cutters can be used for cutting coiled wire, trimming cobbled ends and taking test samples. Valve design permits rapid operating cycle. The number of operating parts has been reduced, and parts are hardened and ground. Floating Meehanite piston allows freedom of alignment and provides large bearing surface. Interchangeable blade and anvil permit wear points to be reversed for longer blade life. Units are available in three models: Model MC-210 has a ½-in. diam capacity, operating cycle of ½ second per cut, and weighs 13 lb; Model MC-35 cuts 1-in. diam steel in 1¼ seconds

—ITEM 278—
For More Information Circle Item Number on Yellow Card—page 19

NOW! 40-micron, self-cleaning filter
It's the new Cuno SUPER Auto-Klean



HOW IT WORKS. Dirty oil enters inlet (1) at left, fills housing (2) and flows through metal edge-type filter (3). Clean oil rises through center of filter, leaves at right. Dirt combed out by cleaner blades (4) is removed through drain (5).

Cuno's new SUPER Auto-Klean is the first practical, compact micronic filter for lubricating oil, hydraulic fluid, coolant, fuel, and other industrial fluids.

Many times smaller than other micronic filters of equal capacity, Cuno's new SUPER Auto-Klean filter now makes possible economical, micronic filtration at high flow rates and eliminates the need for replacement cartridges in most cases. Here's what it offers:

1. Full-flow 40-micron filtration with a self-cleaning filter. Positive protection against particles larger than 40 microns (actually 0.0015 in.). All-metal filter can't rupture or channel.

2. Easy cleaning. Just turn the handle—by hand or continuously with motor drive. No interruptions for cleaning.

3. No cartridge changes. Ends operating costs if you've been using cartridge filters.

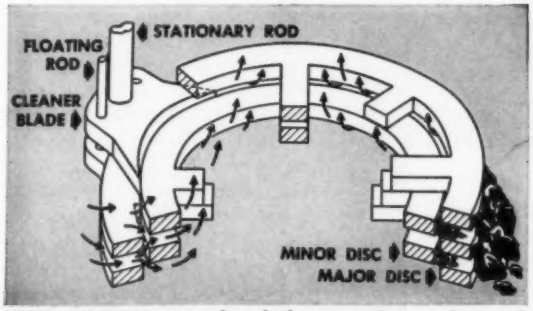
4. Low pressure drop, no pressure drop build-up. An 8" by 2¾" SUPER Auto-Klean filters 30 gpm of 200 SSU oil with only 3 psi pressure drop—up to 75% more with slightly higher pressure.

5. High capacity in a small package. Many times smaller than replaceable-cartridge type filters of equal capacity, it saves with lower initial costs, lower installation costs.

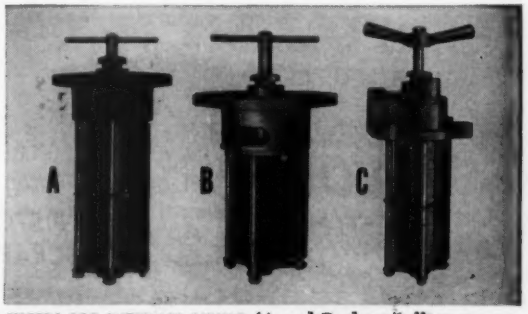
6. Easy to build into new equipment. Available for line-type housings *(left)* or incorporation in sump or reservoir *(below.)* Works in any position.

7. Easy to install in old equipment. Fits existing Auto-Klean housings. You can easily replace most 2¾" diameter elements with SUPER Auto-Klean for finer filtration.

Write today for complete technical data on the new SUPER Auto-Klean for your new or existing equipment. Ask for Catalog No. SAK-057. Cuno Engineering Corporation, 14-3 South Vine Street, Meriden, Connecticut. 59



FILTER ELEMENT consists of stacked major and minor discs and cleaner blade bearing against minor discs. Small arrows show flow. Short restrictions between minor and major discs stop 40-micron particles but allow high flow rate.



FILTERS FOR INTERNAL PIPING *(A and B above)* allow streamlined design plus the best infiltration. Flange mounting with external outlet *(C above)* and line-type *(large cutaway above left)* are just a few of many other possibilities.

CUNO **ENGINEERED FILTRATION**

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous metal)

—ITEM 279—

For More Information Circle Item Number on Yellow Card—page 19

and weighs 44 lb; Model MC-65 cuts 1¼-in. diam steel in 2 seconds per cut and weighs 120 lb. All models are powered by a 5-hp electric hydraulic pump. *Manco Mfg. Co., Bradley, Ill.*

Air Press: Bench-mounted, 1-ton high-speed unit performs looping, bending, forming, coiling and pressing operations for springs and can also be used for light punching, trimming, cutting, crimping and other secondary operations. Production rate is 1800 loops or 3000 punches per hour. The machine is equipped with bolster plate, foot switch, solenoid valves, electrical fittings and air line connections. An adjustable screw stop controls the stroke of the ram up to 2 in.; ram speed is controlled by a valve on the air line. Machine measures 8 x 11 x 22 in. and weighs 115 lb. *Carlson Co., New York.*

Packaging

Package Filler: Model 628 package filling machine fills boxes with a predetermined number of articles such as screws, nails and tacks. The machine handles articles ranging in size from 0.080 to ½-in. shank diam and up to 3½ in. long at a rate of four to six gross per minute. Boxes from 1 to 4 in. long and wide and ¾ to 1 in. high can be filled. Counting range is from 15 to 1000 articles per package. The machine is fully automatic except for loading with empty boxes and refilling the hopper. It operates on 110-v, 60-cycle, single-phase current. *Batchelder Engineering Co. Inc., Springfield, Vt.*

Stapling Machine: Model CSC-2 simultaneously staples tops and bottoms of center-slotted corrugated and fiberboard boxes after they have been packed. The unit is equipped with two stapling heads, the hinged upper head holding 250 staples and the lower head 350 staples. The lower head can be made inoperative while the upper head operates by a stop-cock valve adjustment. Head can be lifted as little as 1 in. to permit rapid movement of box before driving the next staple. Unit is air operated with fully pneumatic controls. Air valves are operated mechanically. Compressed air requirement is 60 psi. Telescoping legs permit adjustment of the conveyor top from 21½ to 33 in. high. The stapler accepts cartons of any length from 2 to 25 in. wide and 2 to 46 in. high. *Container Stapling Corp., Herrin, Ill.*

Parts Counters: Model EC semiautomatic units count small parts in predetermined lots. Counting speed is dependent upon size of parts being counted and packaged. Parts are placed manually in the hopper and packages are placed and removed by hand when count is made. Parts are passed over a "marked insert" located between the bowl feeder and discharge chute. They are separated by the insert to be counted individually by means of a photo beam. Counting is performed automatically up to the preset quantity of pieces. Four machines are available with maximum capacities from 9 to 9999 parts. The units can be automated further by replacing the standard discharge chute, adding a belt conveyor, and adding controls to the circuit. *Pennsylvania Scale Co., Bareville, Pa.*

Processing

Degreasing Machine: Model MSS-321 vibrating unit cleans up to 3000 lb of small metal parts or chips per hour by moving them on a spiral trough through a liquid immersion, liquid rinse and solvent vapor zone. Clean parts are emitted through an unload chute. The spiral trough is attached to flexible, vibrating leaf springs and electromagnets. Speed of the elevator can be varied by a selector switch in the control box. Control unit requires 220-v, single-phase, 60-cycle, 18-amp ac electrical connections. The degreaser is fully enclosed except for small openings for loading and unloading. It requires floor space of 5 x 5 ft and is of heavy-duty steel construction. *Manufacturers Processing Co., Detroit.*

Tubing Marker: Model 48A1 tubing marker automatically feeds, imprints and cuts off polyethylene or vinyl tubing from ¼ to 6 in. long. The machine accepts sizes 12 to 0 tubing, and handles other sizes with some modification. Operating speed is 110 imprints per minute. The unit feeds from a

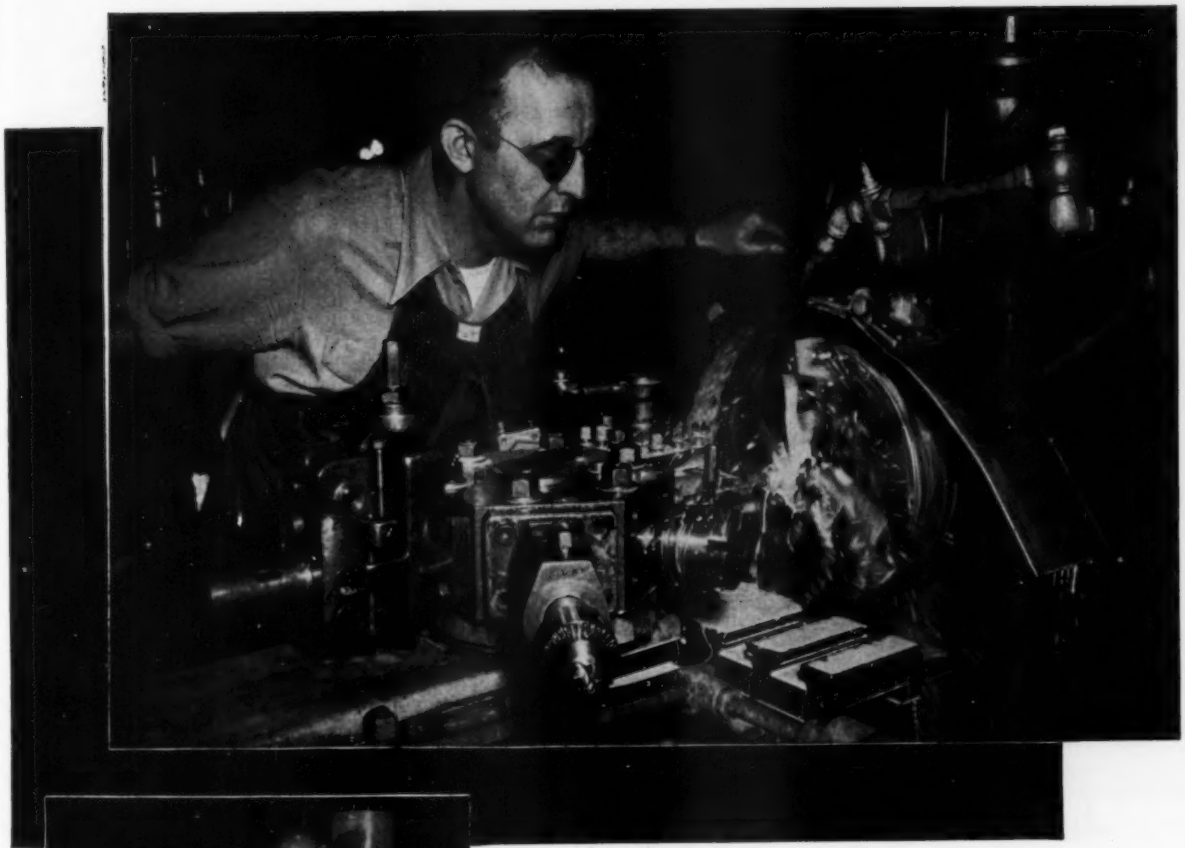
PROTECTS VITAL O-RINGS AND BACK-UPS

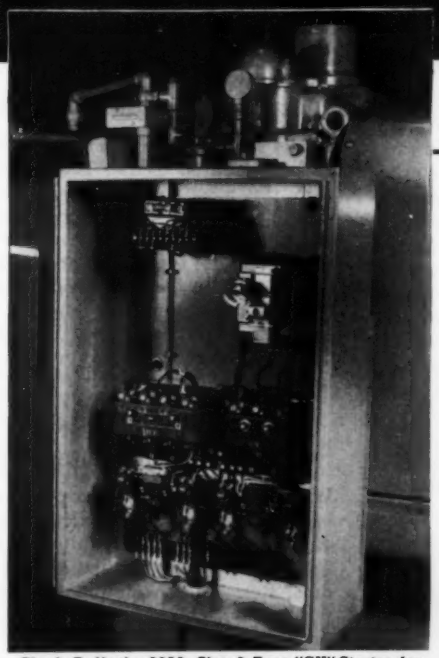
SPECIFY S-11065 Hydraulic Piston Rod Scraper Ring to assure vital seal reliability and to extend packing life in aircraft and industrial hydraulic and pneumatic equipment. Spring loaded, tough, extremely inert and low in friction they are responsive to rod misalignments, and do not score the rod. Interchangeable with AN6231 Scraper Rings to fit standard groove dimensions of AND10075. Also available in KELON-Y (Nylon). Call your Shamban representative or write direct.

KELON

SHAMBAN ENGINEERING CO.
11617 W. Jefferson Blvd., Culver City, Calif.

—ITEM 280—
For More Information Circle Item Number on Yellow Card—page 19





Clark Bulletin 6050, Size 2 Type "CY" Starter for Single Winding 2 Speed Constant Torque A.C. Motor used on Warner & Swasey Universal Turret Lathes.

→ CLARK CONTROLS help Warner & Swasey lathes

"machine better, faster, for less"

● Selected for long, trouble-free performance, Clark Bulletin 6050 Size 2, Type "CY" 2-speed starters are used on Warner & Swasey's No. 5 Universal Turret Lathes. Maintenance and wear on contact tips are reduced to a minimum as a result of an exclusive arc quenching method employed on Type "CY" starters. Effective arc interruption and reduced wear on tips is accomplished by using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation continuously moves the arc from a hot to a cold spot, distributing the heat evenly over entire contact, preventing pitting or "build-up." Tips require no cleaning or dressing over long years of maintenance-free operation.

Write for complete descriptive literature.

The **CLARK** **CONTROLLER** *Company*

Engineered Electrical Control

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—ITEM 281—

XUM

(Advertisement)

Flash-Butt Welding

How to Use It to Improve Product Design and Quality

What is Flash-butt Welding?

Flash-butt welding is a resistance welding process for end to end joining of rods, tubes, bars, forgings, fittings, etc., to achieve the greatest possible strength. It is accomplished by positioning the pieces to be joined with clamping electrodes so that there is initially light contact between abutting edges (Fig. 1).

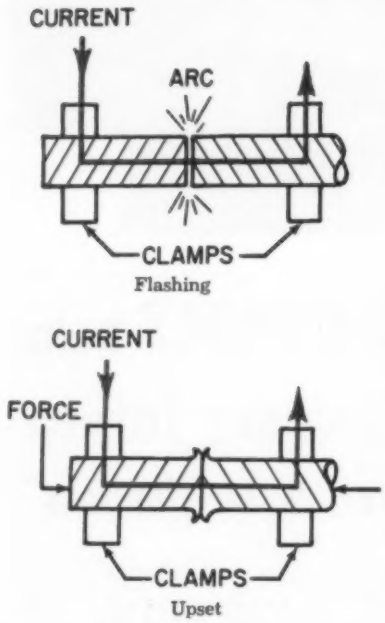


Fig. 1. Flash-butt welding process.

Introduction of the current causes flashing which generates great heat. As the metal is burned away the pieces are moved together in an accelerating motion. Thus, uniform flashing action is maintained for the most efficient heating process. When the inner faces obtain the proper temperature, they are forced together under high pressure and the current is cut off. The impurities (oxides, slag, etc.) formed during flashing are forced out in the upset action leaving pure base metal to form a high strength bond (Fig. 3).

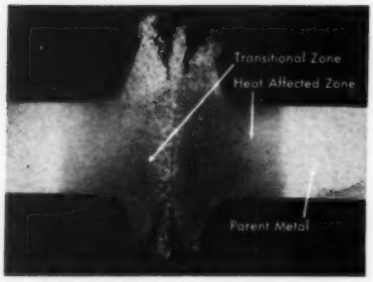


Fig. 2. Macrograph of 2" O.D. x .095" wall of 4140 alloy steel tubing flash-butt welded on a Sciaky Type BMW. 3-400 machine.

Advantages of Flash-butt Welding

Flash-butt welding offers a 100% strength factor compared to 80% strength factor for flame and arc welds. Further, no extra material such as gas, rod, or flux is required. *The material itself forms the weld.*

Flash-butt welding has low power demand and power consumption. Higher production speeds are more readily achieved with this process than with any other fastening method. The localized heat minimizes part distortion. Generally, no special preparation of the weld surfaces is required.

Simplicity and effectiveness of the Sciaky Flash-butt weld technique reduces multi-step fastening operations to just one. One operator (not skilled) can consistently produce high quality welds.

Fig. 3. Destruction test on extruded aluminum miter joint. Note that failure is in parent metal, not in the weld.

Dissimilar metals with widely varying melting temperatures are easily flash-butt welded.

When to Design for Flash-butt Welding

Whenever ideal flash-butt welds are required, the size and shape of the parts to be welded should be identical. However, a maximum of 15% variation in end dimension is usually permissible for commercial usage. New applications for this process are opening up every day. Often little, or no change in existing design allows conversion to high production flash-butt welding.

New Research Center for Your Design Problems

Sciaky's new three-quarter million dollar Research Center is equipped with the most advanced resistance welding machines, testing instruments, and trained personnel. The entire facility is devoted to solving *your* joining problems and advancing the application and development of resistance welding. The Research Center invites *you* to submit your fastening design problems.

Build Your Data File with Free Sciaky Literature

Write today on your company letterhead describing your particular field of interest. We will send suitable back issues (as well as future issues) of our "Resistance Welding At Work" publication, showing typical design problems solved by this method of fastening. All contain impressive case history examples of Sciaky basic thinking—resistance welding techniques designed to do more *useful work* at *lower operating costs* with *maximum reliability.*

Largest Manufacturers of Resistance Welding Machines in the World

SCIAKY®

Sciaky Bros., Inc., 4939 West 67th Street, Chicago 38, Ill., Portsmouth 7-5600

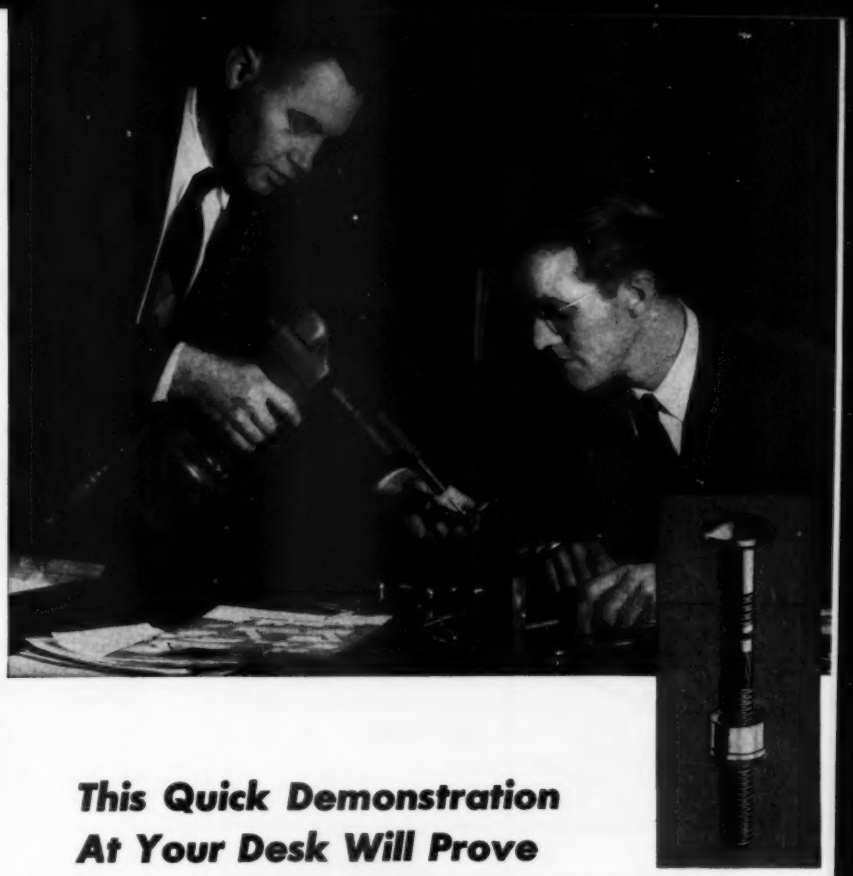
—ITEM 282—

XUM

coil, and uses leaf and a thermostatically controlled heating element to produce an imprint which meets government specifications. Work guides are self-adjusting for height and can be interchanged for various tubing sizes. Maximum imprint length is 3 in.; depth is governed by tubing diameter. Cut-off knife is adjustable to cut on print centers up to 3 in. or can be disconnected entirely. Sliding masterplate and engraved type inserts make possible quick legend change. Leaf is supplied in various colors. *Markem Machine Co., Keene, N. H.*

Rotary Dryers: Ruggles-Coles rotary units are designed for laboratory use and for small capacity processing requiring intermittent or continuous drying. The dryers are compact, are mounted on a structural steel frame, and can be moved from place to place. They are available in mild steel and stainless steel. Model XH-XF is a single-shell, direct-heat, gas-fired unit which can be arranged for parallel or counterflow operation. Model XB, a double-shell, indirect-heat type, is particularly suited for high-temperature drying without contaminations. Model XC, a steam-tube type, is applicable for low-temperature drying. Evaporative capacities are 40 lb per hr for the single-shell type, 25 lb per hr for the double-shell, and 30 lb per hr for the steam-tube unit. *Hardinge Co. Inc., York, Pa.*

Die Casters: Series D die casting machines are available in four capacities from 250 to 850 tons, in either hot or cold-chamber models. The units are equipped with a knuckled wedge cam toggle which automatically takes up clearances in dies caused by heat expansion. Knuckled joint eliminates shear stress on the pins when under locking pressure. Machines equipped with a hot-chamber injection unit have a furnace that can be adjusted from the machine center line to positions below center. Injection cylinder ram is surrounded by a water-cooled jacket. Cold chamber units have injection speeds of approximately 10,000 in. per minute with pressures of about 33,000 psi on the injected metal. Injection cylinder is adjustable from machine center line to below center. *Lake Erie Engineering Corp., Buffalo.*



This Quick Demonstration At Your Desk Will Prove How To Get Better, Economical Fastening With Townsend Lockbolts

A few minutes of your time invested in watching a simple demonstration of a better fastening method may point the way to savings of thousands of dollars in assembly of your products. The Townsend lockbolt provides a quick method of producing tight, rigid fastenings that cannot loosen even under extreme vibration or shock conditions.

We would like to have a Townsend engineer demonstrate to you and others in your organization how these lockbolts combine the advantages of riveting and bolting—eliminate the disadvantages. He will show you that installation is fast—that fewer workers can complete an assembly in less time—you improve your product—achieve a lower installed cost.

You will be able to see why the clamping action, or clinch, of Townsend lockbolts is higher than rivets—is more uniform than bolts and nuts. The demonstration will explain how the lockbolt fills the hole better than other fasteners—makes possible a more rigid joint and provides an effective liquid seal.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16" and 3/8" diameters, in grip length ranging up to 2", in various head styles.

For a demonstration on how to speed production, get tight, secure, permanent fastening with Townsend lockbolts write on your company letterhead to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

Licensed under Huck patent nos. RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049.

Townsend
COMPANY • ESTABLISHED 1816
Sales Offices in Principal Cities

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CIRCLE CLAMPS provide the best Clamping Action available today!

plus...

- Lower Initial Cost
- Fast Mounting
- Easy Field Replacement
- Wide Range of sizes
- Accommodates all Hose Variations
- Available in SAE 1010 Steel with a CYANIDE ZINC, ELECTRO-PLATED finish
- Pneumatic tools are easily adaptable for fast, efficient mounting of clamps in mass production applications

Write for complete descriptive information, stock sizes and prices to

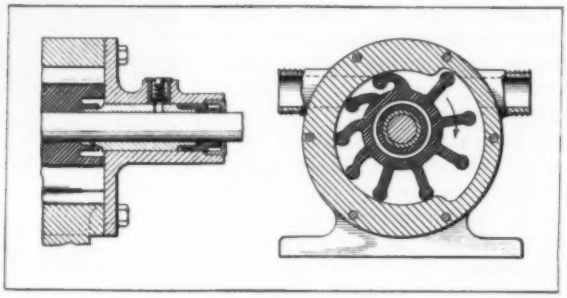
Circle Clamp Corporation
39 Broadway, New York 6, N. Y.

—ITEM 284—

NOTEWORTHY Patents

Rubber Vane Pump

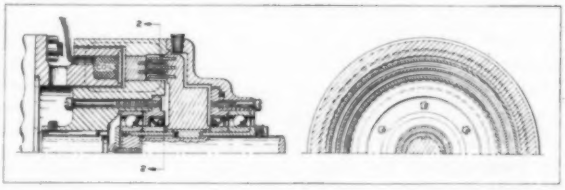
Flexible vanes provide a leaktight shaft seal in a rotary vane pump design. Molded fingers in the hub for the vane members act as a seal around the



shaft. Sealing effectiveness of the fingers is increased as pressure increases. *Patent* 2,711,136 *assigned to Cascade Pump Co. by A. W. Arnold.*

Magnetic Particle Clutch

Concentric, cylindrical elements, designed to avoid packing of dry or wet particle mixtures comprise the poles of a magnetic particle clutch. The cylindrical elements attached to the driving member "mesh" with the elements of the driven member. Leaking of the magnetic particle mixture is prevented by



completely enclosing the driven member by the driving member. A stationary electromagnet energizes the particle mixture through an air gap. Thus, slip rings, which would be required for rotating coils, are not necessary. *Patent* 2,709,507 *assigned to Vickers Inc. by P. H. Trickey.*

Overload-Release Clutch

Power is transmitted between rotating clutch elements by means of a pin-and-socket connection. During normal operation, the pin carried by the driven member is held in engagement with a spring-loaded socket on the driving member by a back-up plate. When an overload occurs, the pin rides out of the

ACADIA

MEETS YOUR SYNTHETIC RUBBER NEEDS

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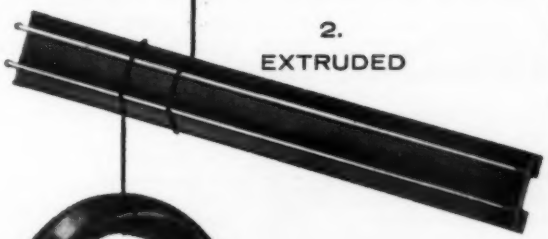
OUT OF 3 WAYS!



And when there's another way to form synthetic rubber, you can be sure it will be available from Acadia!

Right now Acadia is precisely meeting all manner of rubber specifications. Very often Acadia helps users to find a better, less costly way.

For in addition to the complete choice of shape, size or method, Acadia offers its wide experience in developing special rubber properties. Here you get exactly the characteristics you want—*strength, compression-deflection, resistance to oil, age or what have you.* Here, too, is the remarkable Acadia SILICONE rubber that stays resilient at 100° *below zero*, or 500° above. It's available molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings.

Would you like further information about Acadia synthetics for *your* product? A letter or postcard will bring an Acadia representative at your convenience.

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DIVISION OF WESTERN FELT WORKS
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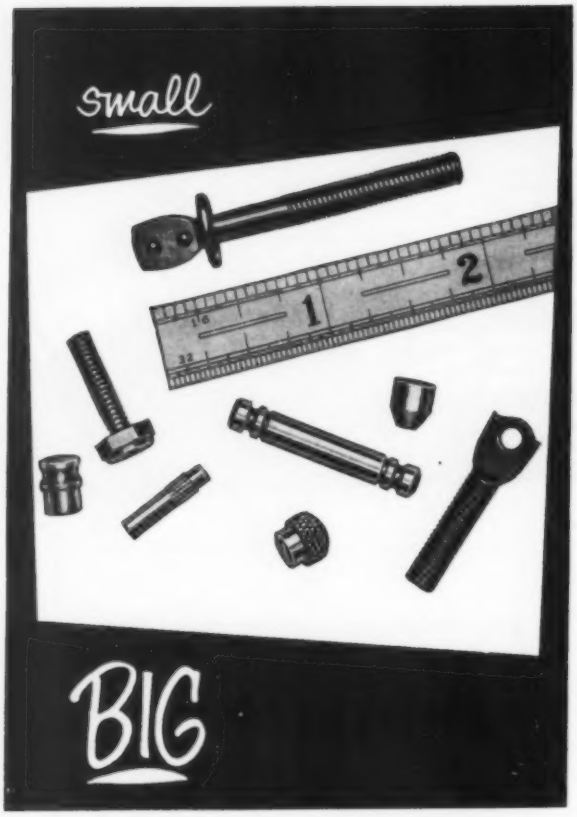
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

—ITEM 285—
For More Information Circle Item Number on Yellow Card—page 19



Here are a few parts turned out on high-speed multiple-spindle automatic screw machines in quantity. Some are complete as they drop from the machine.

Others require additional finishing operations, like the largest piece, a special 10-32 collar screw with head formed and flattened on a punch press, *triple-lead* roll-threaded and then copper plated.

Your requirements may be for smaller or larger pieces. Western's capacity ranges from 1/16 to 4¾" round, with *all* necessary finishing equipment for such secondary operations as milling, drilling, threading, tapping, heat-treating and grinding.

For fast, reliable delivery, precision quality and low cost, it pays you to put WESTERN on your production team.

Why not send us your blueprints for quotations . . . today?

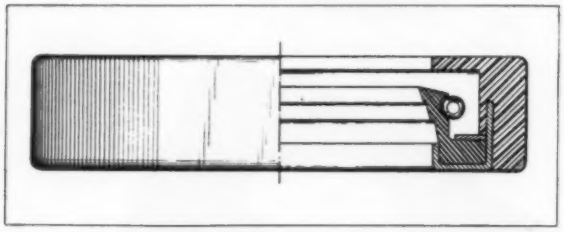
The Western Automatic Machine Screw Company
division of Standard Screw Company
383 Woodland Ave., Elyria, Ohio
Precision Parts and Assemblies Since 1873

Noteworthy Patents

socket, disengaging the power connection. At the same time, the back-up plate is caused to rotate, lining up a hole in the plate with the pin. This hole permits the pin to snap back and remain out of engagement with the socket. The pin remains disconnected from the socket until the back-up plate is rotated manually to force the pin back into engagement. Springs of different strength may be employed to vary the overload limit. *Patent* 2,712,372 *assigned to Phoenix Gage Co. by L. Scusa.*

Low-Friction Shaft Seal

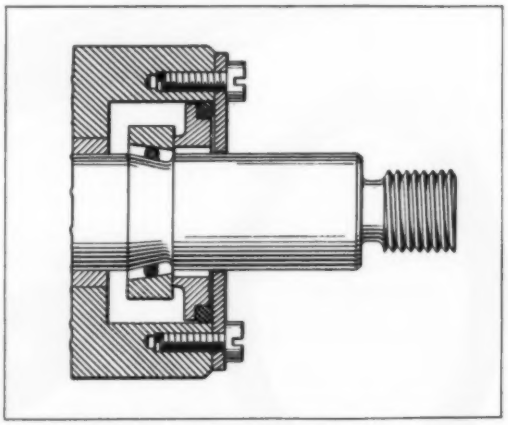
Leaktight seal for rotating shafts consists of a plastic outer shell into which the seal assembly is mounted. An internal groove in the plastic shell holds a metal clamping ring in which a rubber shaft-



sealing element is attached. Sealing contact between the rubber element and the shaft is maintained by a garter spring. *Patent* 2,709,098 *assigned to Victor Mfg. & Gasket Co. by T. O. Kosatka.*

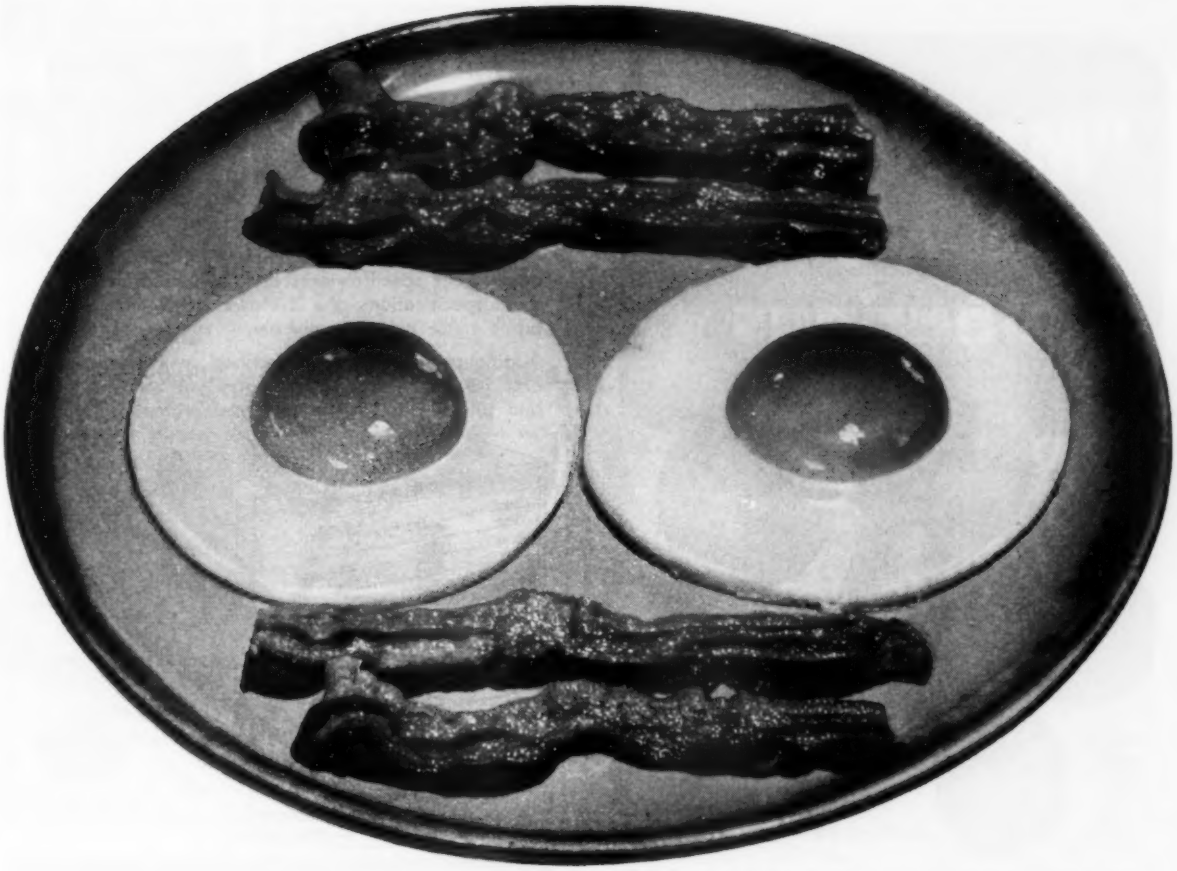
Self Aligning Seal

Shaft seal consists of a stationary metal ring floating on a rubber O-ring. In contact with the sealing face of the stationary ring is a rotating metal ring whose inside bore is a conical surface. A corresponding conical surface on the shaft is



separated from the inner surface of the rotating ring by a second O-ring. Design of the working surfaces is such that the O-rings are automatically positioned after a few turns of the shaft. *Patent* 2,710,206 *assigned to New York Air Brake Co. by M. W. Huber.*

—ITEM 286—
For More Information Circle Item Number on Yellow Card—page 19



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Laminated plastics . . . for a combination of properties that *can't* be beat

SYNTHANE is a favorite material among engineers, designers, and product-conscious executives because it possesses a combination of many properties. It is light in weight, strong; has high dimensional stability, excellent electrical properties and chemical resistance. It's also easy to fabricate.

Synthane makes excellent ball bearing retainers. High dimensional stability, wear resistance and non-galling properties keep bearings humming smoothly at 100,000 rpm and up! Synthane's light weight minimizes the effect of any eccentricities, provides lower starting torques, less bearing weight. The Synthane plant has facilities for producing practically every type of laminated plastic retainer known.

Property combinations! Synthane has them . . . in over 30 individual grades . . . sheets, rods, tubes, moldings and completely fabricated parts. Send for free illustrated catalog today.

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DIELECTRIC STRENGTH

TENSILE STRENGTH

CHEMICAL RESISTANCE

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

—ITEM 287—

For More Information Circle Item Number on Yellow Card—page 19

"MONOBALL" Self-Aligning Bearings

PATENTED U. S. A.
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CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

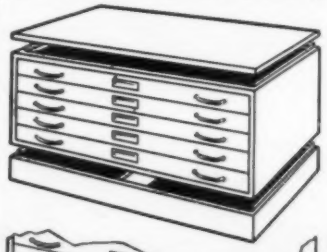
—ITEM 288—

MAYLINE

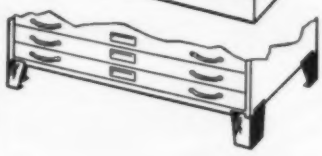
MAYLINE Steel Plan Files Meet Specifications

Mayline Steel Blue Print Files meet present rigid government specifications, and in accordance with those specifications, the 5-drawer units, caps, and bases stack and intermember.

Additional features are described in Folders S-20 and S-5. Have your dealer give you more details and price. He can promise you prompt delivery.



Symbol of Superiority



MAYLINE CO.
601 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE
—ITEM 289—

Get Greater Accuracy In Your Stamped Gears

EACH WINZELER STAMPED GEAR, in runs of hundreds or *thousands*, equals or surpasses the most exacting specifications. They invariably cut assembly time, and costs. Mechanisms run smoother, sweeter, longer. And users like the quiet, dependable performance of WINZELER Geared products. Send along drawings, specifications, quantities needed. Let our capable staff help you.

SEND FOR *useful 4-page folder . . a valuable Stamped Gear guide. Gives technical data, tables, ideas, suggestions, descriptions of many types. Use company stationery please!*

WINZELER MANUFACTURING & TOOL CO.
1712 WEST ARCADE PLACE, CHICAGO 12, ILLINOIS

—ITEM 290—

For More Information Circle Item Number on Yellow Card—page 19

XUM

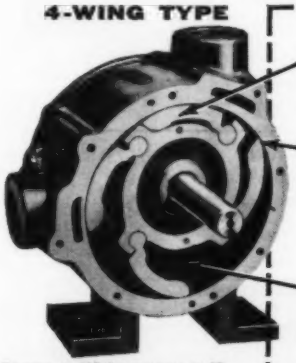
Exclusive Features of

LEIMAN Rotary Air and VACUUM PUMPS

bring you

★ High Vacuum
★ Greater Volume
★ Smaller Size
★ Lifetime Operation

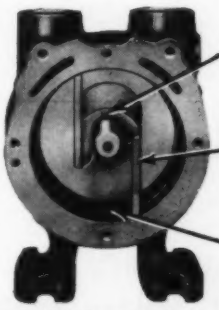
4-WING TYPE



Vacuums to 20" Hg.; pressures to 15 psig.; displacement to 162 c.f.m.

- Curved Wings on easy-action hinge, maintain continuous wall contact.
- Cast Iron Wings and Cylinders hone themselves to hard, glassy smoothness—take up their own wear—assure leak-proof seal for years.
- Extra-large Air Space provides greater capacity, permits use of smaller pump.

2-WING TYPE



Vacuums to 29.9" Hg.; pressures to 20 psig.; displacement to 40.8 c.f.m.

- Automatic Wing Adjuster assures wing-to-wall contact, prevents sticking, guarantees positive action.
- Extra-long Steel Wings (not composition) provide long wear. Cylinder walls made of durable cast iron.
- Large air space provides more compact pump.

Install LEIMAN AIR PUMPS

for dependable Vacuum (Suction) and Pressure

FREE ENGINEERING DATA

- *Application Book* showing 60 "how-to-do-it" blueprints of actual applications.
- 16-page Catalog showing construction, types, sizes, capacities, etc.

Precision-made, compact Leiman Air Pumps have fewer moving parts — no tips or blades to renew — need no maintenance except occasional oiling — run for 10, 15 and 20 years without trouble or shutdown. Over half a million installed. Consult our engineers on any air application.

SEE OUR CATALOG IN SWEET'S FILE

LEIMAN BROS., Inc.

148 Christie St., Newark 5, New Jersey

—ITEM 291—

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coiled aluminum tube readily available for lubricating lines, fuel lines, air lines, hydraulic fluid lines

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ALCOA Utilitube will not cause sludge or gum formations . . . will not contaminate the fluids it carries. Its light weight makes economical long lengths —up to 1,000 feet—easier to handle.

For more information on this versatile product, write today for the FREE booklet, *Alcoa Utilitube*. Contains complete information on how to put this money-saving tube to work for you.

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ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

ALUMINUM COMPANY OF AMERICA
909-C Alcoa Building, Pittsburgh 19, Pennsylvania

—ITEM 292—

from the hand of
the Specialist . . .
TO YOUR *Specifications*

ERIE Bolts • Studs • Cap Screws • Nuts
In Alloys • Stainless • Carbon • Bronze

Only the hands of the specialist can produce fasteners which will meet your design and engineering specifications with precise accuracy. Erie has been doing just that for more than 40 years . . . producing to customer specifications bolts, studs, cap screws and nuts for use in extreme temperature, corrosion and tensile applications for a wide diversity of industries. Submit your specifications to us with confidence.

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BARIUM STEEL CORPORATION
WORKING IN STEEL, ALUMINUM, MAGNESIUM, FIBERGLASS

ERIE BOLT & NUT CO.
Erie, Pennsylvania
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AUTOMATIC CLUTCHES AND TRANSMISSIONS

for Gasoline Engines
Gas Turbine Engines
Electric Motors

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SALSBURY CORPORATION

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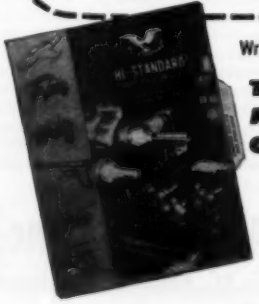
In Steel . . . Stainless . . . Brass . . .
Aluminum . . . Titanium . . . and Wood

HI-STANDARD Deep-Hole Drills give you . . . at lower cost . . .

- Exacting Hole Diameters
- Unlimited Hole Depth
- Exceptional Hole Concentricity Throughout
- Improved Hole Surface Finish
- More Pieces Between Grinds



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THE HIGH STANDARD MANUFACTURING CORPORATION
Hamden, Connecticut

Pioneers and Makers of Deep-Hole Drills For More Than 30 Years ★

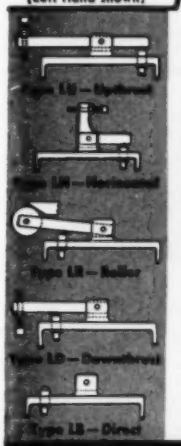
—ITEM 295—

XUM

Pneu-Trol TIME DELAY CONTROL SWITCH

...Gives Cylinder Applications Greater Efficiency Accuracy ...Wider Use!

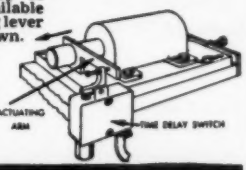
For any type actuation Left or Right Hand. (Left Hand shown)



- Holds Cylinder dwell accurately to fraction of second.
- Automatically re-sets.
- Simple, Compact, Rugged.

You can hold any motion or operation controlled or actuated by air or hydraulic cylinders at a positive stop on either end of the stroke for ¼ to 60 seconds in 20 to 1 ratios with Pneu-Trol Time Delay Control Switches. Simple in design with positive hydraulic timing action . . . compact and easily mounted on the machine or fixture, Pneu-Trol Switches are providing millions of trouble-free actuations in solenoid-operated cylinder applications of every type. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of the dwell. Available with 5 actuating lever linkages as shown.

Switch mounted to provide dwell at end of power stroke of single action, spring return cylinder.



Pneu-Trol DEVICES, INC.

1316 N. KEATING AVENUE • CHICAGO 51, ILL.

—ITEM 296—

Equal power with fewer belts . . .

NEW BROWNING SUPER GRIPBELTS

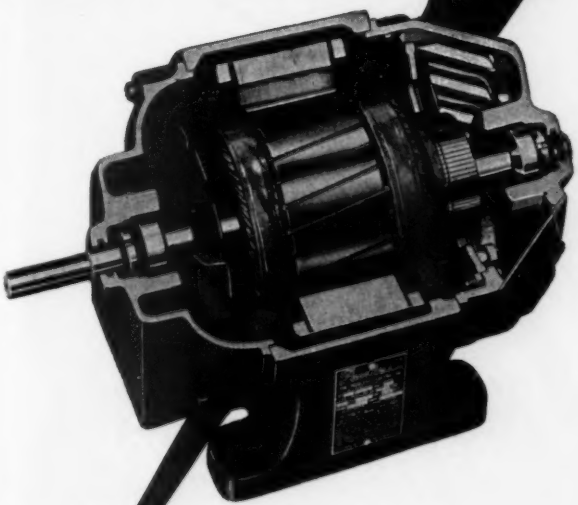
Illustration shows how 20 Browning Super Gripbelts can deliver same power as 30 standard belts, saving space and reducing sheave cost. Improved synthetic cord construction provides far greater strength and safety margin, better grip, less slip. Minimum stretch, maximum flexibility, simplified matching.

Ask your Browning distributor or write us for Bulletin 2019.

Browning MANUFACTURING COMPANY
MAYSVILLE, KENTUCKY

—ITEM 297—

SMOOTH TRANSITION in REPULSION-INDUCTION MOTORS



Buried Bar Type BH
by *Peerless*®

Speed-torque characteristics remain smooth from standstill to full speed on this Peerless Type BH Repulsion-Induction motor. Designed without a centrifugal switching or short-circuiting mechanism, it affords even transition from repulsion to induction characteristics. When operating on low voltage, Type BH runs at proportionately lower speed with satisfactory results. It's the ideal single phase motor for air compressors, floor sanders, hoists, and many general purpose applications where low voltage conditions prevail. Oversize commutator provides excellent commutation and long brush life. Over 15 years' successful field service from BH motors is your guarantee of top performance. Models from 1-5 HP are rated at 1750 RPM; 3/4-3 HP rated at 1150 RPM.

Teamwork of Peerless and OEM engineers has solved hundreds of special motor problems. Custom mountings, windings and minor modifications are developed to suit any application. Submit your motor requirements to Peerless. We'll help you select the one motor that operates your product best.

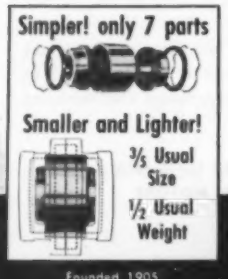
Write for Bulletin SDA-150 for details on REPULSION-INDUCTION MOTORS

ELECTRIC MOTOR DIVISION
THE *Peerless-Electric*® COMPANY
FANS • BLOWERS • ELECTRIC MOTORS • ELECTRONIC EQUIPMENT
1520 W. MARKET ST. • WARREN, OHIO

—ITEM 298—

Where horsepower loads are heaviest . . . that's where Sier-Bath Flexible Couplings are stand-outs in performance and economy! Not only are Sier-Bath Coupling capacities higher for any given shaft size from 3" to 12", but also their *initial cost to you averages 21-percent lower* (compared to four other leading brands).

You save many ways with Sier-Bath Couplings, because simplicity of design makes possible great savings in space and weight, requiring *less* shaft space for assembly . . . and use of snap-rings instead of flanges and bolts cuts assembling and uncoupling time to seconds, eliminating special tools. Lower moment of inertia reduces bending stresses on shafts, saves bearing wear.



Sier-Bath Flexible Gear Couplings are available in many standard and special types in sizes from ⅞ to 12. Horsepower ratings range from 4 to 4500 HP/100 rpm.

Complete catalog information will be sent on request

Sier-Bath GEAR and PUMP CO., Inc.

Founded 1905
Member A.G.M.A.

9254 HUDSON BLVD., NORTH BERGEN, N. J.

—ITEM 299—

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AVAILABLE: Mechanical Engineer, ASME, 52, over 20 years all around experience in mechanical design, applied mechanics, research, production, and administration; expert in design and analysis of high speed machinery and mechanisms; creative mind, several inventions; desires responsible position. Address Box 893, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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A leading A A A rated multiple-plant manufacturer of parts for all industries needs an additional:

Sales Engineer
Production Engineer
Process Engineer

to take care of expanding business in new products.

Real opportunities with a strong, growing, established company.

Good working conditions in a pleasant Midwest city.

Excellent insurance, hospitalization and retirement benefits.

For information concerning these outstanding engineering opportunities,

Write Box 892, Machine Design, Penton Bldg., Cleveland 13, Ohio

(Our employees know of this advertisement)

—ITEM 300—

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*made to S.A.E. and Federal Govt. Specifications

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CONTINENTAL FELT *fills hundreds of jobs daily.*

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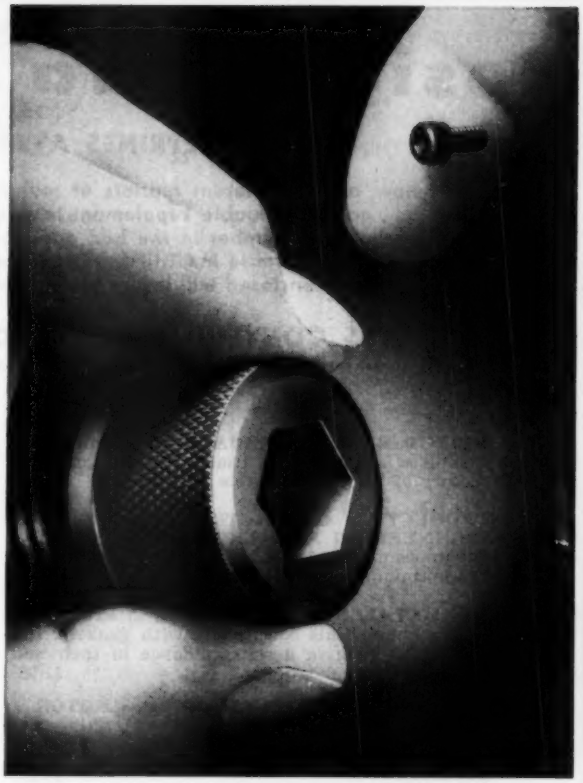
—ITEM 301—



Sizes from 1⅛ inch to No. 0 wire size.

Bristol Hex Socket Cap Screws mark your product "precision made"

The high quality and pleasing appearance of Bristol's Hex Socket Cap Screws will reflect the precision you've built into your product.

Perfectly squared-up heads and shoulders of these screws give them a smooth, accurate, and well-designed look. Their diamond-knurled heads make them easier to insert, to start and to spin up finger-tight. And, of course, they can be internally wrenched up permanently tight.

We've made precision instruments at Bristol for 66 years and socket screws for more than 42. In fact, we originated the famous Bristol Multiple-Spline Socket Screw. That's why we know Bristol Hex Socket Cap Screws can meet your design or assembly needs exactly.

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SOMETHING REVOLUTIONARY IN THE FIELD OF FASTENERS WILL BE ON DISPLAY in Bristol's Booth No. 541 at the American Society of Tool Engineers Show in Chicago, March 19-23. If you use socket screws you can't afford to miss the first showing of this brand new development.

Precision Socket Screw Manufacturers Since 1913

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½"

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

—ITEM 303—

KNOW HOW and RESPONSIBILITY are behind "WHEELS by F&H

Our constant search for wheel improvement takes ALL factors into account—

- The design of WHEELS and HUBS
- The design of SPINDLES and AXLES
- Selection of adequate anti-friction BEARINGS
- Selection of suitable closure SEALS
- Selection of types and sizes of rubber TIRES

INTEGRATED ENGINEERING
F&H
Since 1888

May we assist you in cost reduction through our **PACKAGE PLAN?**

FRENCH & HECHT
DIVISION
KELSEY HAYES WHEEL COMPANY
DAVENPORT, IOWA

—ITEM 302—

design data

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SMALL MIRROR PART REFLECTS 66% SAVING: GRC DIE CASTING ELIMINATES SCRAP LOSS

Brass screw machine part made from bar-stock meant big scrap loss, high cost; Gries die cast part means no scrap loss; costs only ⅓rd as much!

This rear view mirror component was an expensive part of the assembly when made of brass because so much costly metal was completely lost in machining (see diagram). Gries' die casting of the same part completely eliminates the scrap loss. In addition, Gries' design flexibility permitted casting the part with a "material-saver," for further cost reduction. The brass part actually was 3 times more costly than the Gries zinc die cast part!

BRASS SCREW MACHINE PART showing scrap loss

GRC DIE CASTING designed for minimum metal usage

GRC's exclusive die-casting methods produce finished tiny parts, trimmed, ready-for-use, in one high-speed automatic operation . . . at low, *low* tool cost. The rear view mirror part is being die cast less wastefully, less expensively, and more uniformly, at high production rates.

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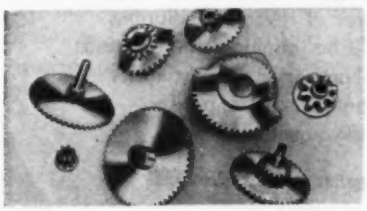
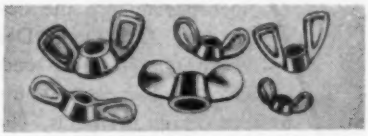
Send for your copy of Gries' new, informative Die Casting Bulletin.

GRC DIE CASTS GEARS AND PINIONS IN ONE PIECE FOR LOWER UNIT COSTS



Lower cost, improved design, faster production is possible because GRC gears and pinions are die cast in *one* piece. These one-piece zinc alloy assemblies can be die cast with shafts or center holes, or in combination with cams, hubs, spacers, flanges, etc. Many combinations are available from stock dies for less precise applications at no tool charge. Special designs and close-tolerance requirements are produced at nominal tool charges.

Maximum size of Gries' gears and pinions is 1-5/16" O.D. x 1/16" face width; on the smaller diameters wider faces can be furnished. They are available in quantities from 100,000 to millions. Write for catalog sheet, samples.



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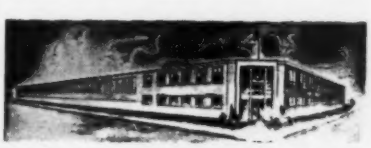

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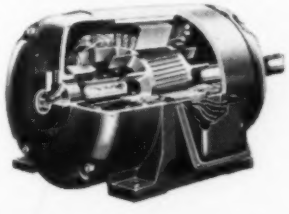

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MASTER UNI-BRAKE MOTORS

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BECAUSE it has no cams to change, this Warner & Swasey 2AC Single Spindle Chucking Automatic sets up fast like a turret lathe, gives you automatic operation without the usual time-consuming setup procedures.

And among the many design features contributing to the lasting production accuracy of the 2AC is the mounting of the spindle on Timken® tapered roller bearings.

Because of their tapered design, Timken bearings take radial and thrust loads in any combination, hold the spindle in rigid alignment.

Full line contact between Timken bearing rollers and races provides maximum load-carrying capacity. And, because Timken bearings are built to last the life of the machine, maintenance costs go down.

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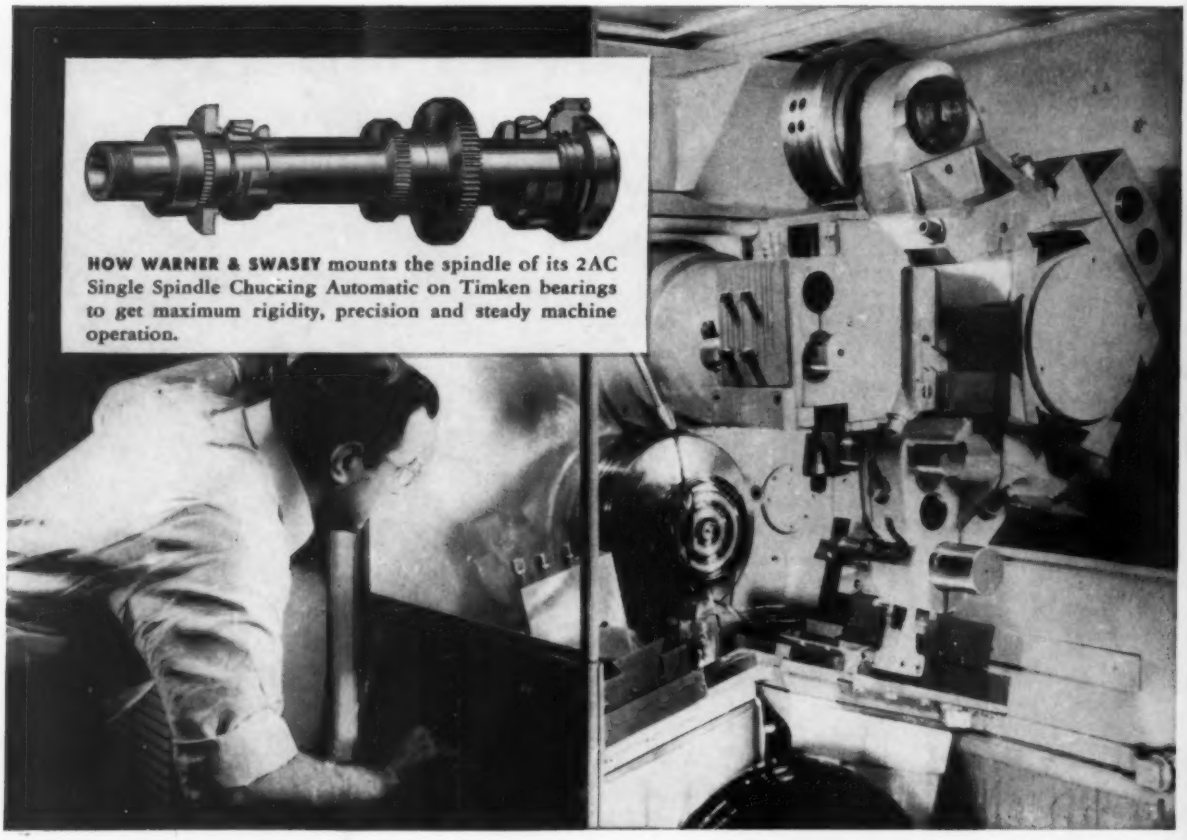
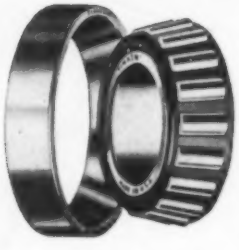
This symbol on a product means its bearings are the best.

HOW WARNER & SWASEY mounts the spindle of its 2AC Single Spindle Chucking Automatic on Timken bearings to get maximum rigidity, precision and steady machine operation.





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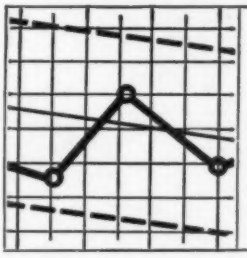

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